NASA CR- 144779

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HUGHES AIRCRAFT COMPANY

(NASA-CR-144779) TRILATERATION RANGE AND RANGE RATE SYSTEM. VOLUME 2: TARS SYSTEM MANUAL (Hughes Aircraft Co.) 59 p HC $4.50 CSCL 17B

N76-28266

Unclas

G3/17 45898

TRILATERATION RANGE AND RANGE RATE SYSTEM

VOLUME II. TARS SYSTEM MANUAL

FEBRUARY 1976

CONTRACT NAS 5-21629
HUGHES REF NO. C3074 * SCG 60048R

CONTENTS

ILLUSTRATIONS

TABLES

1. INTRODUCTION

1.1 SCOPE OF DOCUMENT

This document is one of a series of manuals designed to provide the information required to operate and maintain the Turn-Around Ranging Station (TARS) of the Trilateration Range and Range Rate (TRRR) System, as furnished by Hughes Aircraft Company to the National Aeronautics and Space Administration under Contract No. NAS-5-21629. The function of each manual is as follows:

1) Volume I, Command and Data Acquisition (CDA) System Manual contains information pertaining to the equipment in the Trilateration Range and Range Rate System which is designed to interface with existing NASA equipment located at Wallops Island, Virginia.

2) Volume II, Turn-Around Ranging Station (TARS) System Manual contains information pertaining to the equipment located in the Turn-Around Ranging Station.

1.2 GENERAL DESCRIPTION OF TRRR SYSTEM

The Trilateration Range and Range Rate system is described in the following paragraphs.

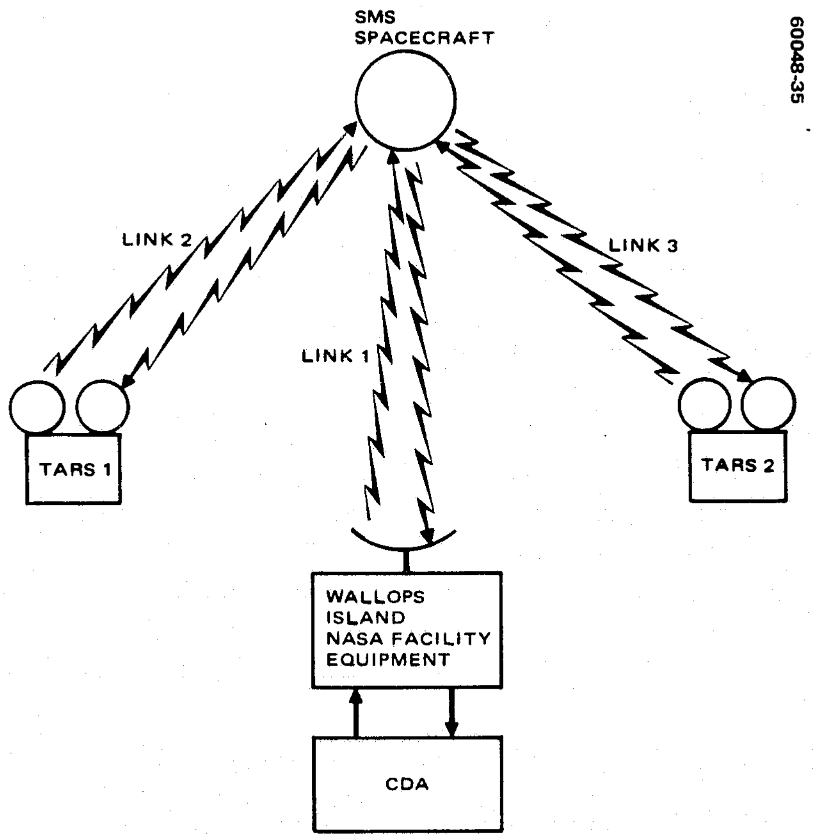
1.2.1 Physical Description of TRRR System

The TRRR System consists of three basic units that are physically independent of each other. (See Figure 1-1.) These units are as follows:

1) The Master Range Station of the CDA System for the Synchronous Meteorological Satellite (SMS) located in the NASA facility at Wallops Island, Virginia

2) The Turn-Around Ranging Station located at the NASA facility on OAHU, Hawaii, designated TARS 1

3) The Turn-Around Ranging Station located near Santiago, Chile, designated TARS 2



LINK 1 - CDA TO SMS TO CDA
LINK 2 - CDA TO SMS TO TARS 1 TO SMS TO CDA
LINK 3 - CDA TO SMS TO TARS 2 TO SMS TO CDA

FIGURE 1-1. TRILATERATION RANGE AND RANGE RATE SYSTEM

All Master Station (CDA) electronic equipment is located in two standard racks within the Operations Area of the NASA facility. All TARS electronic equipment is located within a weatherproof shelter, while the antennas and associated equipment are mounted on the exterior of the shelter.

1.2.2 Functional Description of TRRR System

The TRRR System contains transmitters, receivers, and other equipment which provide the capability of simultaneous range and range rate information for the SMS. This information, derived from data acquired from the CDA and the two TARS, is gathered at the CDA for additional analysis.

In general, the range and range rate information is derived in the following manner. (See Figure 1-2.) A ranging signal is developed in the CDA and transmitted to the NASA Wallops Island station modulator and upconverter for frequency conversion. This signal is then amplified and transmitted to the SMS at the proper frequency and power levels. When the signal is received by the satellite, it is automatically downconverted and retransmitted through the satellite antennas back to earth to be received by the CDA, TARS 1, and TARS 2. When the signal is received, each TARS reacts by transponding a signal, again at the proper frequency and power levels, back to the SMS which again downconverts and retransmits the signal back to the CDA. Although they receive the newly transmitted signal, each TARS is mechanized to respond only to transmissions initiated at the CDA. In addition, sufficient guard bands have been engineered into the system to ensure isolation between the TARS.

On receipt of the transmissions from the TARS, three range/time intervals can be measured and stored by a computer in the CDA:

1) CDA to SMS to CDA

2) CDA to SMS to TARS 1 to SMS to CDA

3) CDA to SMS to TARS 2 to SMS to CDA

By measuring successive range/time intervals, the system is capable of resolving range rate information of the SMS in addition to range.

Upon receipt of the above data, the CDA assembles the following information into a serial data format suitable for transmission on demand over a standard telephone line:

1) Range/time interval

2) Range rate

3) Wallops Island facility antenna azimuth and elevation angle

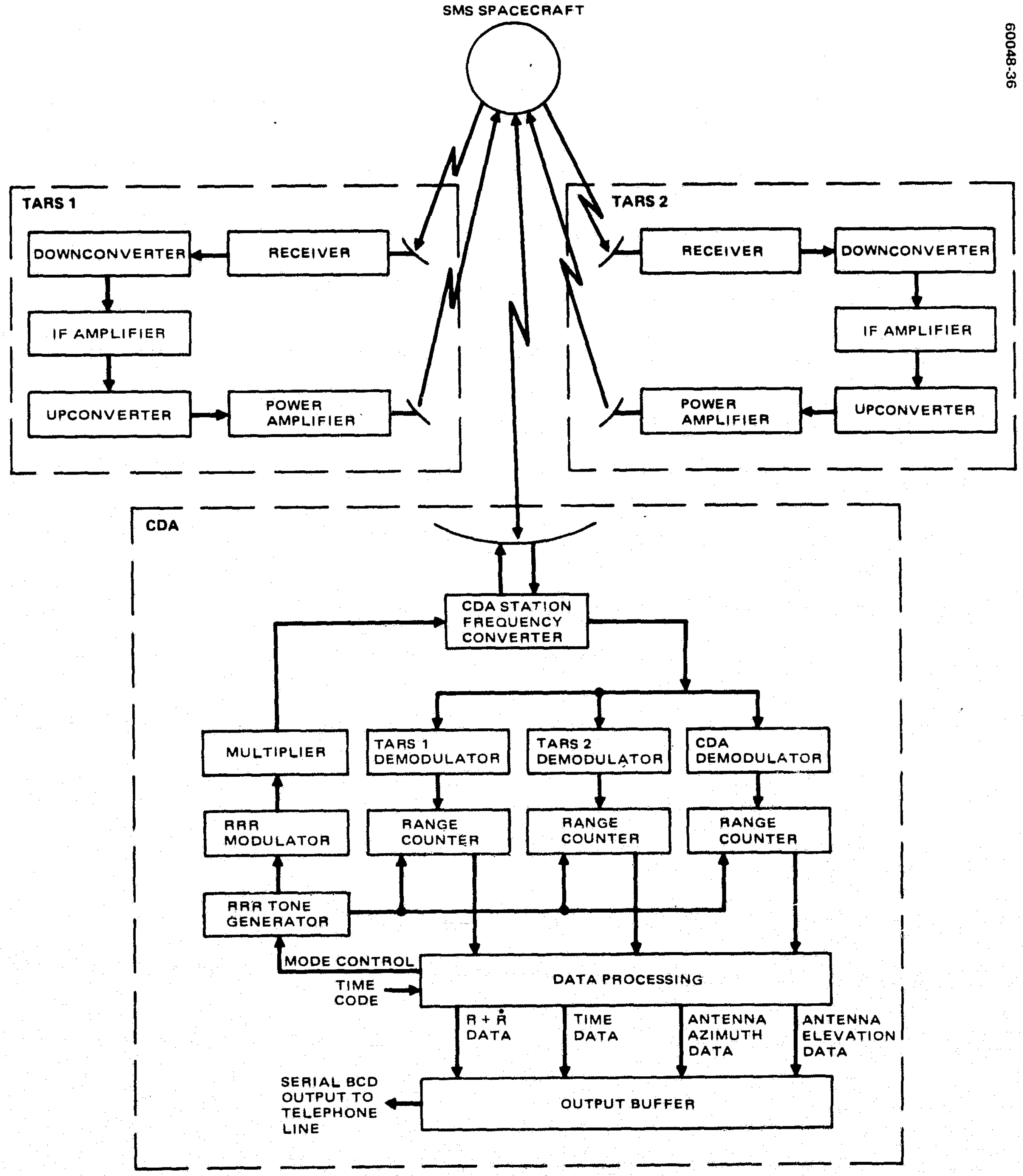


FIGURE 1-2. TRRR SIMPLIFIED BLOCK DIAGRAM

4) Time of year in days, hours, minutes, and seconds

5) Data source identification (CDA, TARS 1 and 2, and SMS)

6) SMS housekeeping telemetry (spacecraft temperature, SMS system delay)

7) CDA delay

The entire TRRR operation, including spacecraft acquisition, multiple data measurement, data multiplexing, and transmission, is designed not to exceed 11 minutes with the total spacecraft time allocation for the operation not to exceed 10 minutes.

An orderwire function is provided between the CDA and each TARS to ensure a coordinated operation in the event that field alignment or repair of TARS is required.

1.3 GENERAL DESCRIPTION OF TARS

1.3.1 Physical Description of TARS Equipment

The principal units that comprise each TARS are as follows:

1) Antenna subsystem

   a) Two 6 foot diameter reflectors (one receive, one transmit)

   b) Two S band feeds (one receive, one transmit)

2) Transmitter subsystem — one power amplifier unit (two TWTs)

3) Receiver subsystem — Single-stage transmitter amplifier

4) Ground communication equipment

   a) S band upconverter

   b) S band downconverter

   c) IF amplifier unit

   d) Orderwire unit

5) Power equipment

All the above units are mounted either in racks within an environmentally controlled shelter, or as in the case of the antenna subsystem, on the exterior surface of the shelter. (See Figures 1-3 and 1-4.)

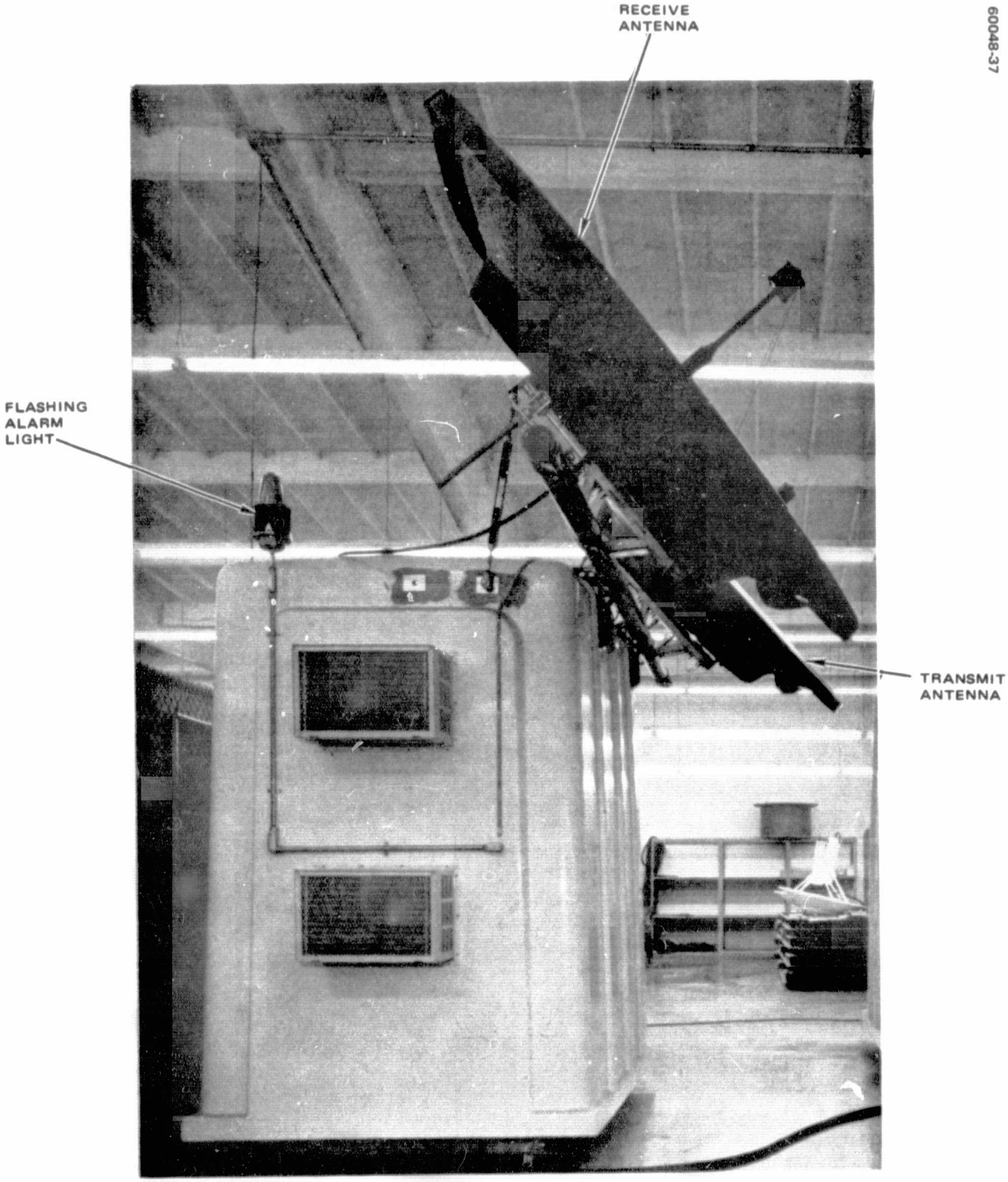


FIGURE 1-3. TARS TERMINAL, EXTERIOR VIEW (PHOTO 4R25712)

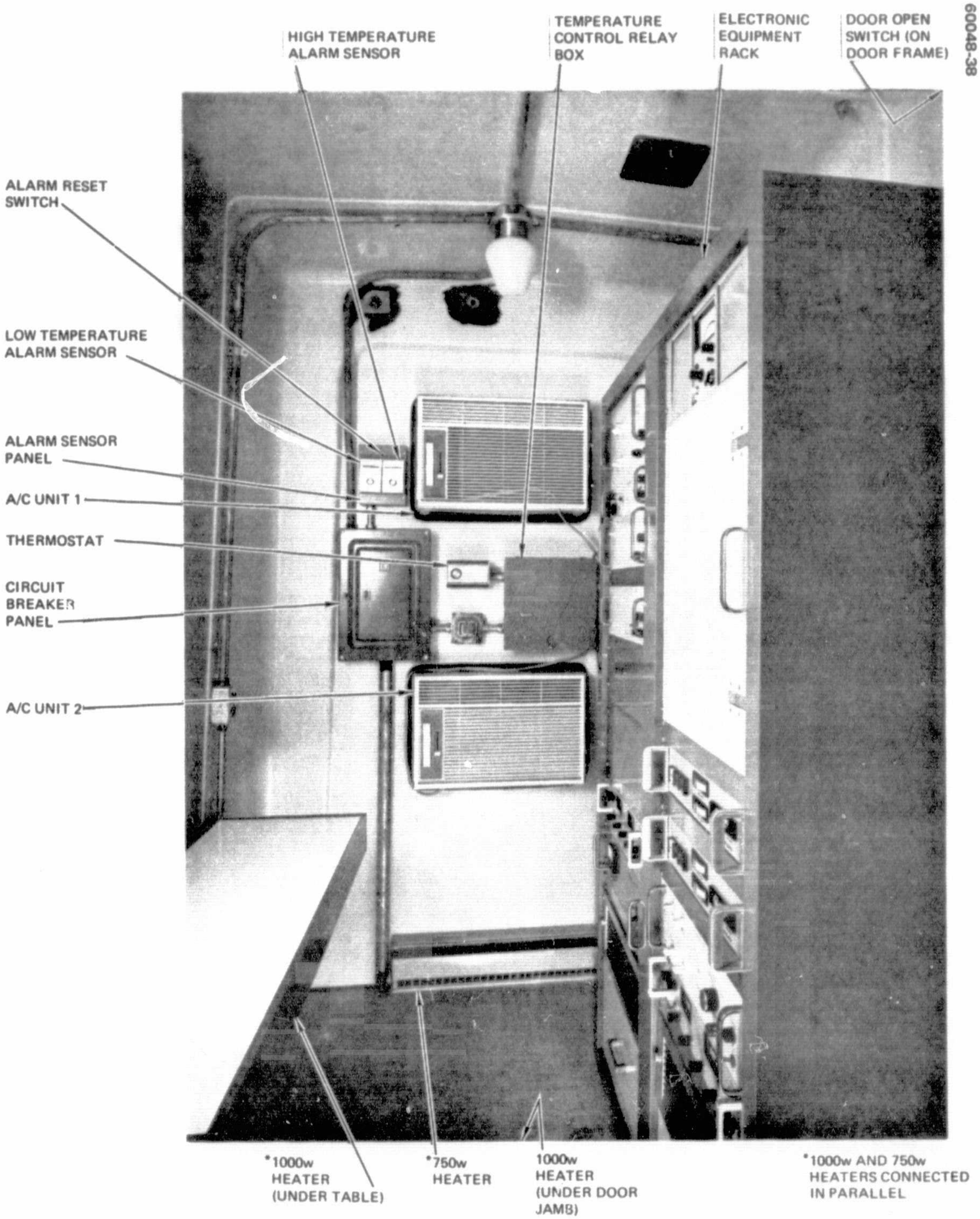


FIGURE 1-4. TARS TERMINAL, INTERIOR VIEW (PHOTO 4R24515)

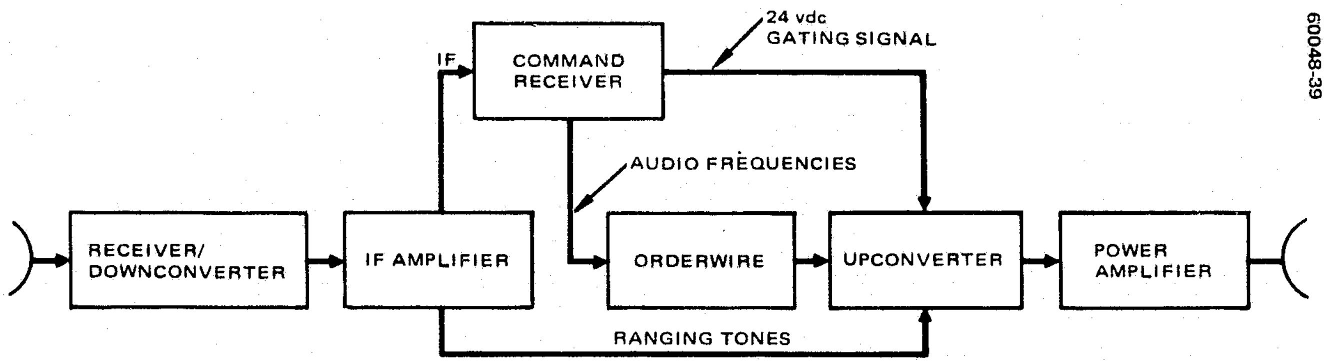


FIGURE 1-5. TARS SIMPLIFIED BLOCK DIAGRAM

In addition to the above, the shelter contains strip heaters and airconditioning units, each with associated sensors, which are designed to maintain the interior of the shelter in a controlled environment.

1.3.2 Functional Description of TARS Equipment

Each of the TARS contains sufficient S band equipment to provide a remote transponding function such that a signal received through the Synchronous Meteorological Satellite is amplified, downconverted to an IF frequency, upconverted, amplified, and retransmitted back to the CDA through the SMS. The time functions from the signals received at the CDA from each of the TARS are factored with the signal transponded from the SMS to the CDA to provide extremely accurate satellite ranging information (to approximately 1 foot) and extremely accurate rate of change of rate information (to approximately 4×10^{-5} m/sec).

Figure 1-5 is a block diagram that illustrates the manner in which the units of the TARS are integrated to perform this function.

1.4 EQUIPMENT CHARACTERISTICS

The TARS equipment in the Trilateration Range and Range Rate System is described in the following paragraphs.

1.4.1 Primary Power Characteristics

All power required by the equipment in the TARS is supplied from 120 volt, single-phase, 60 Hz power from a standard power line derived from either a Government-furnished source or from a commercial system. The power is supplied to the TARS equipment to a circuit breaker panel through a 100 ampere service main circuit breaker. Each circuit breaker in the panel is rated for a maximum load of 20 amperes. Alternatively, the TARS can be strapped for 220 volts, 50 cycle operation.

1.4.2 Performance Characteristics

The TARS equipment is designed to perform ranging functions in conjunction with the Command and Data Acquisition terminal and the Synchronous Meteorological Satellite. The system, subsystem, and unit parameters that are required to perform these functions in the TARS are provided in Tables 1-1 through 1-5.

TABLE 1-1. SMS SATELLITE PARAMETERS

Transmitter power (hard limited), dBm	43.0
Transmitter feed loss, dB	-3.4
Transmit antenna gain, dB	19.1
Transmit off-beam center loss, dB (at 9 degrees)	-2.5
Transmit off-beam center loss, dB (at 7 degrees)	-1.6
Receive antenna gain, dB	13.4
Receive feed loss, dB	-4.5
Receive off-beam center loss, dB (at 9 degrees)	-2.8
Receive off-beam center loss, dB (at 7 degrees)	-1.4
Receive noise temperature (TE = 1630°K), dB/°K)	32.1
Bandwidth, MHz	8.2
Polarization loss, dB	-0.2
Antenna polarization	Linear
Local oscillator stability	
Long term, per year	1.8×10^{-6}
Short term, per 1/2 second	1×10^{-9}
Synchronous orbit, degrees	2 inclined

TABLE 1-2. CDA STATION PARAMETERS

Transmitter power, dBm	48.0
Transmitter feed loss, dB	-1.6
Transmitter antenna gain, dB	48.0
Transmit off-beam center loss, dB (at 0.25 degree)	-1.0
Receive antenna gain, dB	48.0
Receive off-beam center loss, dB (at 0.25 degree)	-0.7
Receive feed loss, dB	-0.4
Receive noise temperature (Te = 100°K), dB/°K	20.0
Polarization loss, dB	-0.2
Transmit frequency, MHz	2026.000
Receive IF, MHz	70.2; 68.0; 64.0
Transmit IF, MHz	66.0

TABLE 1-3. TARS STATION PARAMETERS

Transmit power, dBm	46.0
Transmit loss, dB	-1.7
Transmit antenna gain (8 foot diameter), dB	31.8
Transmit off-beam center loss, dB (at 2.2 degrees)	-3.0
Transmit frequency, MHz	
TARS 1	2030.200
TARS 2	2032.200
Receive antenna gain (8 foot diameter), dB	30.4
Receive off-beam center loss, dB (at 2.2 degrees)	-2.4
Receive feed loss, dB	-0.7
Receive noise temperature, dB/°K (630°K)	28.0
Receive frequency, MHz	1684.000
Local oscillator stability	
Long term, per year	1×10^{-6}
Short term, per 1/2 second	2×10^{-10}
Polarization loss, dB	-0.2 dB

TABLE 1-4. TRRR RF CARRIER UTILIZATION

Links		Frequency, MHz
CDA		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to CDS)	1684.0
TARS 1		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to TARS 1)	1684.0
Uplink	(TARS 1 to SMS)	2030.2
Downlink	(SMS to CDA)	1688.2
TARS 2		
Uplink	(CDA to SMS)	2026.0
Downlink	(SMS to TARS 2)	1684.0
Uplink	(TARS 2 to SMS)	2032.2
Downlink	(SMS to CDA)	1690.2

TABLE 1-5. TARS RECEIVE BAND BASEBAND FREQUENCIES

Modes/Tones	Frequency	
Ranging Modes		
Mode A	35.4	Hz
	283.4	Hz
	3.968	kHz
	27 77	kHz
	200.0	kHz
Mode B	283.4	Hz
	3.968	kHz
	27.77	kHz
	200.0	kHz
Mode C	3.968	kHz
	27.77	kHz
	200.0	kHz
Command Tones		
TARS 1	2940	Hz
TARS 2	3180	Hz
TARS 3	3625	Hz
TARS 4	3925	Hz
Orderwire Ringing Tone	4525	Hz

1.5 EQUIPMENT REQUIRED

The equipment required in the TARS to conduct the ranging function and provide interfacing with the CDA and the SMS is described in the following paragraph.

1.5.1 Major Equipment

Table 1-6 lists the major equipment supplied with the TARS.

TABLE 1-6. TARS SUPPLIED MAJOR EQUIPMENT

Item	Equipment	Manufacturer	Part Number
1	Receiver/downconverter unit	Hughes	3029312
2	Orderwire unit	Hughes	3029306
3	IF amplifier unit	Hughes	3029313
4	Command receiver unit	Hughes	3029308
5	DC power supply (2)	Hewlett-Packard	HP6265B
6	AC regulator unit	Sorensen	ACR2000
7	Power meter	Hewlett-Packard	HP432A
8	Power amplifier (2 TWTs)	Varian	VTS2603C1
9	TWT power supply (2)	Varian	VPW2806A1
10	Upconverter	Hughes	3029314

2. INSTALLATION

2.1 INTRODUCTION

This section provides information designed to illustrate the manner in which the Turn-Around Ranging Station (TARS) terminal is configured for ranging operations after arrival at the operational area. This information is provided in the following order:

1) Shelter Orientation Procedures — See paragraph 2.2

2) Antenna Orientation Procedures — See paragraph 2.3

3) Antenna Polarization Procedures — See paragraph 2.4

2.2 SHELTER ORIENTATION PROCEDURES

Figure 2-1 illustrates the manner in which the TARS shelter is clamped to the concrete foundation. Two modified U-channels are bolted to the bottom of the fiberglass structure. When properly positioned over the clamping mechanism tracks on the concrete foundation, a clamp can be used to fix the position of the shelter on the foundation by clamping the lower edge of the structure channel to the clamping mechanism track. As the receive and transmit antennas are adjustable to plus and minus 10 degrees in azimuth, coarse azimuth adjustments must be made by physically moving the shelter.

Although no formal procedures are required for positioning the shelter on the foundation, the following functions are to be considered prior to completing any orientation procedures:

1) Locate TARS on a concrete pad to an accuracy of $\pm 5^{\circ}$ azimuth.

2) Drill holes adjacent to turnbuckle mounting straps. Use 1/2 inch Red Head anchor bolts.

3) Secure TARS to anchor bolts by tightening turnbuckles.

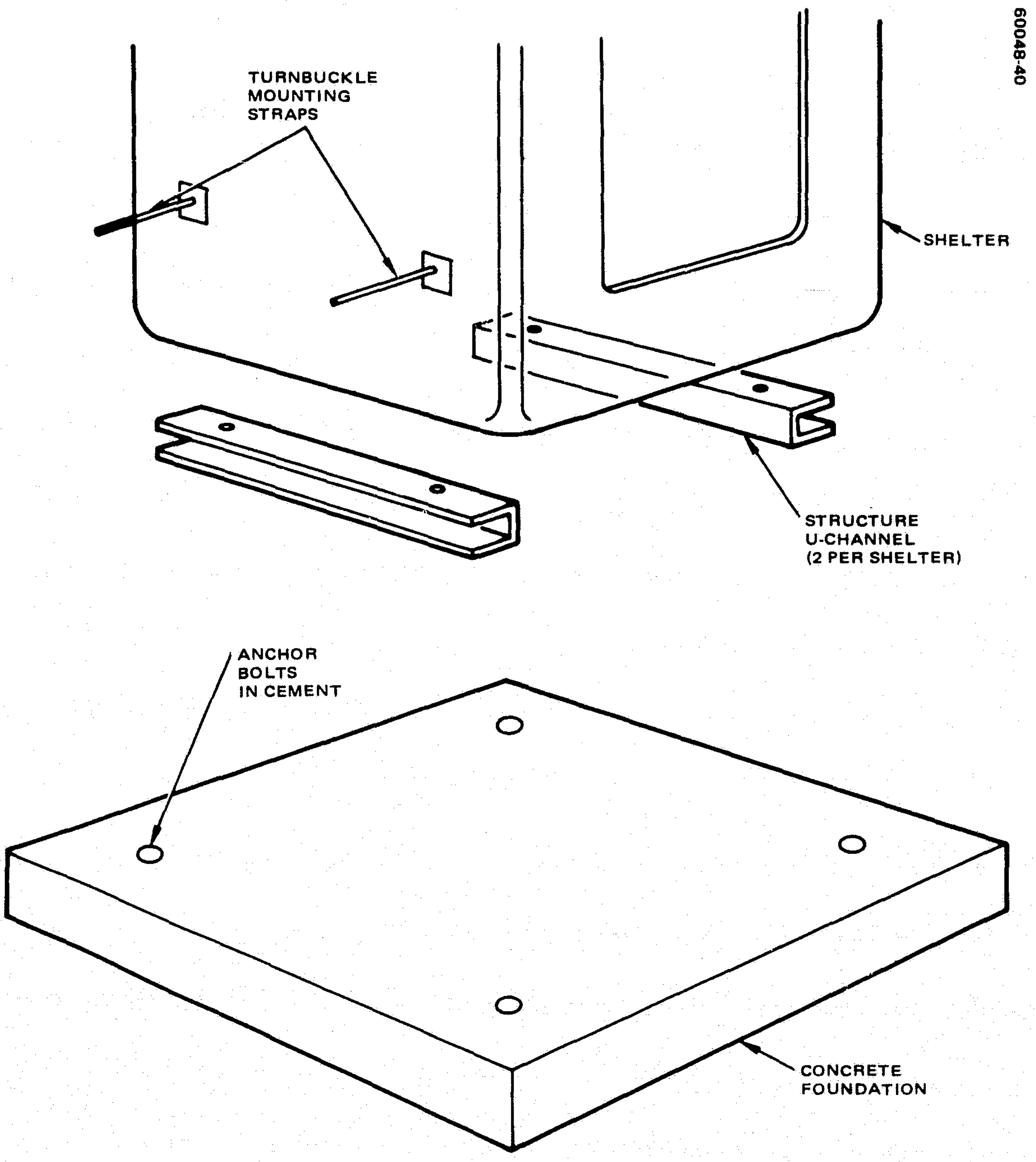


FIGURE 2-1. TARS TERMINAL CLAMPING MECHANISM

2.3 ANTENNA ORIENTATION PROCEDURES

The procedures to be used to reorient the transmit or receive antennas of the TARS are given in the following paragraphs. It should be noted that although the positioning of the elements is different, the mounting mechanism for the transmit and receive antennas is essentially identical.

2.3.1 Antenna Orientation in Azimuth

To orient the TARS antenna in azimuth, perform the following:

1) Loosen, but do not remove, retaining nuts on azimuth control U-bolts (11 and 13, Figure 2-2).

2) Loosen, but do not remove, azimuth adjust anchor bolt (2).

3) Loosen, but do not remove, inner or outer azimuth adjust nut (4), as required, to move antenna reflector (9) in the required direction.

CAUTION

The length of the azimuth adjust bolt (3) is calibrated to allow an angular adjustment of the antenna reflector to within plus or minus 10 degrees in azimuth. Any attempt to move the reflector to a greater angle could cause the azimuth adjust bolt to slip off the elevation axis clamp. If required, reset the shelter position on concrete foundation. (See paragraph 2.2.)

4) Manually set the antenna reflector angle in accordance with provided spacecraft position predictions.

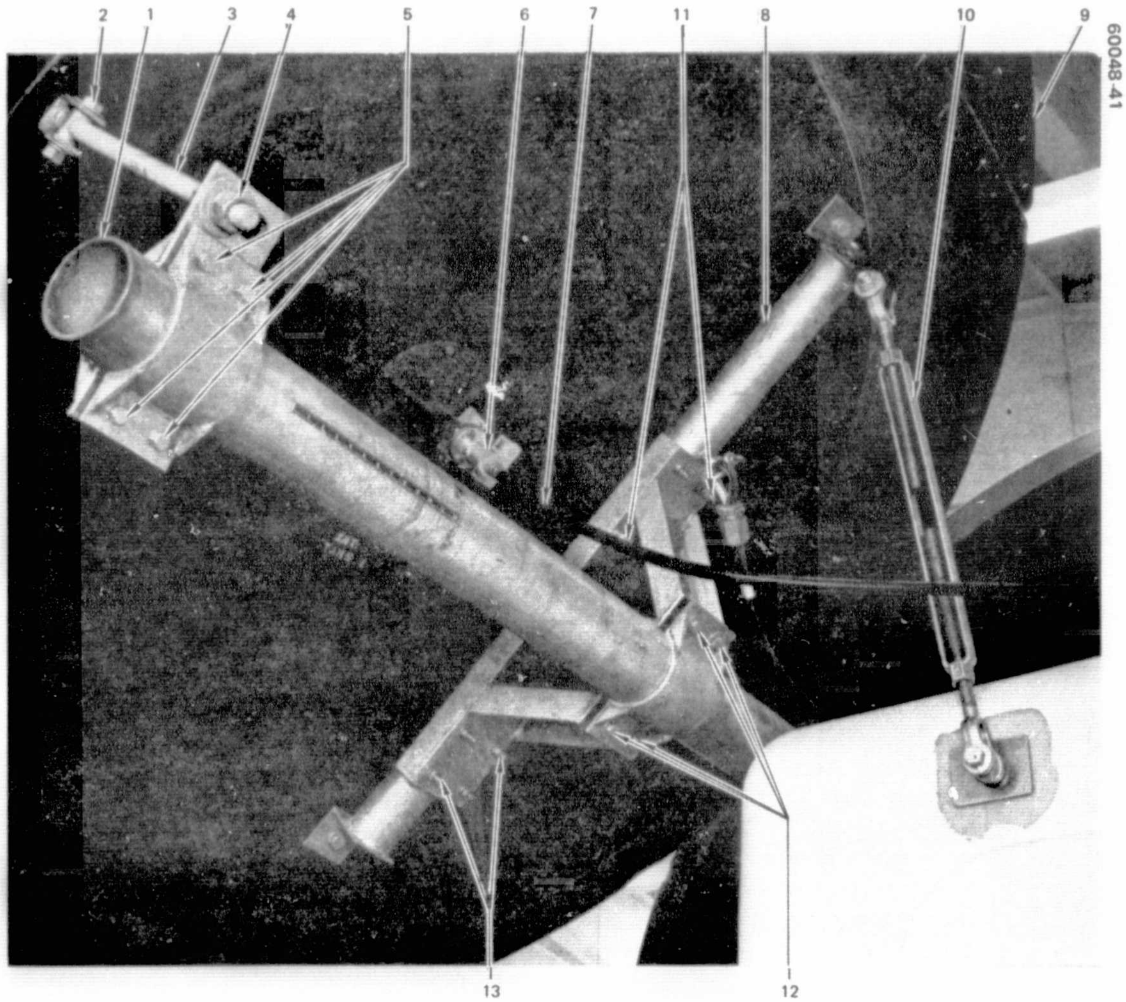
Note

In the following steps, ensure that all bolts are tightened to approximately 160 in-lb prior to proceeding to the next step.

5) Tighten inner or outer azimuth adjust bolt (4), as required.

6) Tighten azimuth adjust anchor bolt (2).

7) Tighten retaining nuts on azimuth control U-bolts (11 and 13).



1) MAIN SPAR
2) AZIMUTH ADJUST ANCHOR BOLT
3) AZIMUTH ADJUST BOLT
4) AZIMUTH ADJUST NUT AXIS
5) ELEVATION/CLAMP BOLTS (4)
6) TRANSMIT FEED CONNECTOR
7) TRANSMIT COAXIAL CABLE
8) AZIMUTH SPAR
9) TRANSMIT REFLECTOR
10) TURNBUCKLE
11) AZIMUTH CONTROL U BOLTS (2)
12) ELEVATION AXIS CLAMP BOLTS (4)
13) AZIMUTH CONTROL U BOLTS (2)

FIGURE 2-2. ANTENNA MOUNT DETAILS (PHOTO 4R25709)

2.3.2 Antenna Orientation in Elevation

To orient the TARS antenna in elevation, perform the following:

1) Loosen but do not remove elevation axis clamp bolts (5 and 12, Figure 2-2).

CAUTION

In the following step, do not attempt to adjust the elevation angle of the antenna by removing either of the end fittings of the turnbuckle. Removing either end of the turnbuckle from the mount will cause the antenna reflector to swing about the main spar (1) in an unpredictable manner which can cause injury to personnel or damage to the equipment or both.

2) Adjust the antenna reflector in elevation by turning the body of turnbuckle (10), as required.

3) Tighten elevation clamp bolts (5 and 12) to approximately 160 in-lb.

2.4 ANTENNA POLARIZATION PROCEDURES

The polarization of the antenna feed is accomplished manually by adjusting the feed connector (6, Figure 2-2) at the end of the coaxial cable (7). Using the information in Figure 2-3 as a reference, adjust the polarization angle of the antenna feed by performing the following:

1) Loosen, but do not remove, the clamp.

2) Rotate the coaxial cable coupling until the polarization index is at the desired angle. (Straight up or down is 0 degree; right or left is 90 degrees.)

3) Tighten the clamp until fitting is secure in its mounting.

4) If required, tighten coaxial cable connector.

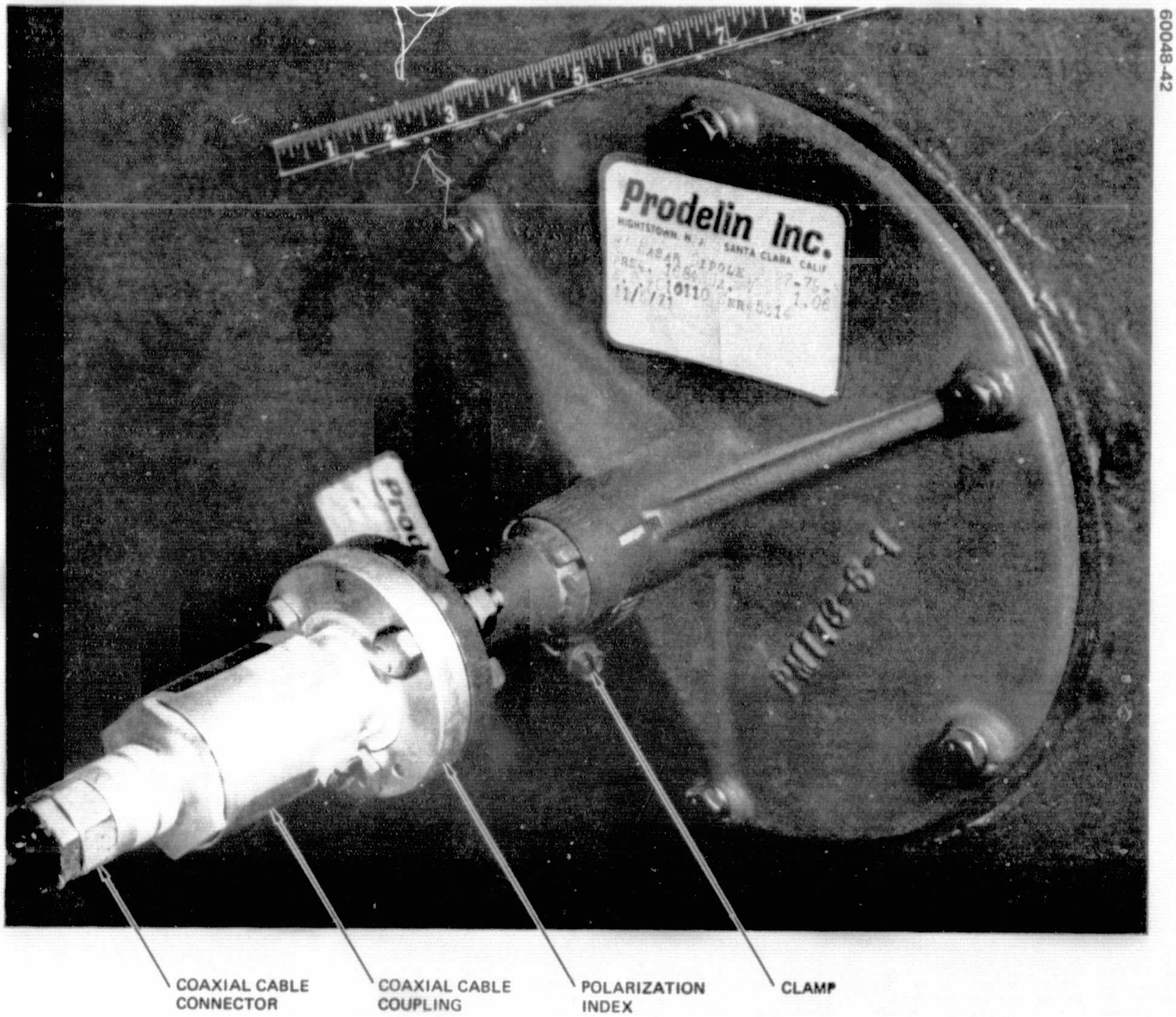


FIGURE 2-3. FEED POLARIZATION ADJUSTMENT (PHOTO 4R25711)

3. OPERATION

3.1 INTRODUCTION

This section provides a description of the location and function of each of the controls and indicators that will be used in the normal operation of the TARS terminal. In addition, this section provides all procedures required for the normal operation of the equipment in the terminal, including equipment preparation for use, power turn-on, and power turn-off.

3.2 PREPARATION FOR USE

No special procedures are required to convert the TARS terminal from a standby (or power-off) condition to an operational configuration.

3.3 LOCATION AND FUNCTION OF TARS CONTROLS AND INDICATORS

The location and function of those units which are unique to the TARS terminal are contained in the following paragraphs. The units discussed below are presented in the following order:

1) Units Mounted on Exterior of Shelter

2) Units Mounted Inside Shelter

The location and function of units not included in the following paragraphs are discussed in the appropriate commercial handbook provided in this series of manuals.

3.3.1 Units Mounted on Exterior of Shelter

The only indicator mounted on the exterior of the shelter is the alarm light which has a negative logic function. (See Figure 1-3.) Under normal conditions, the light flashes green to indicate that the sensed functions

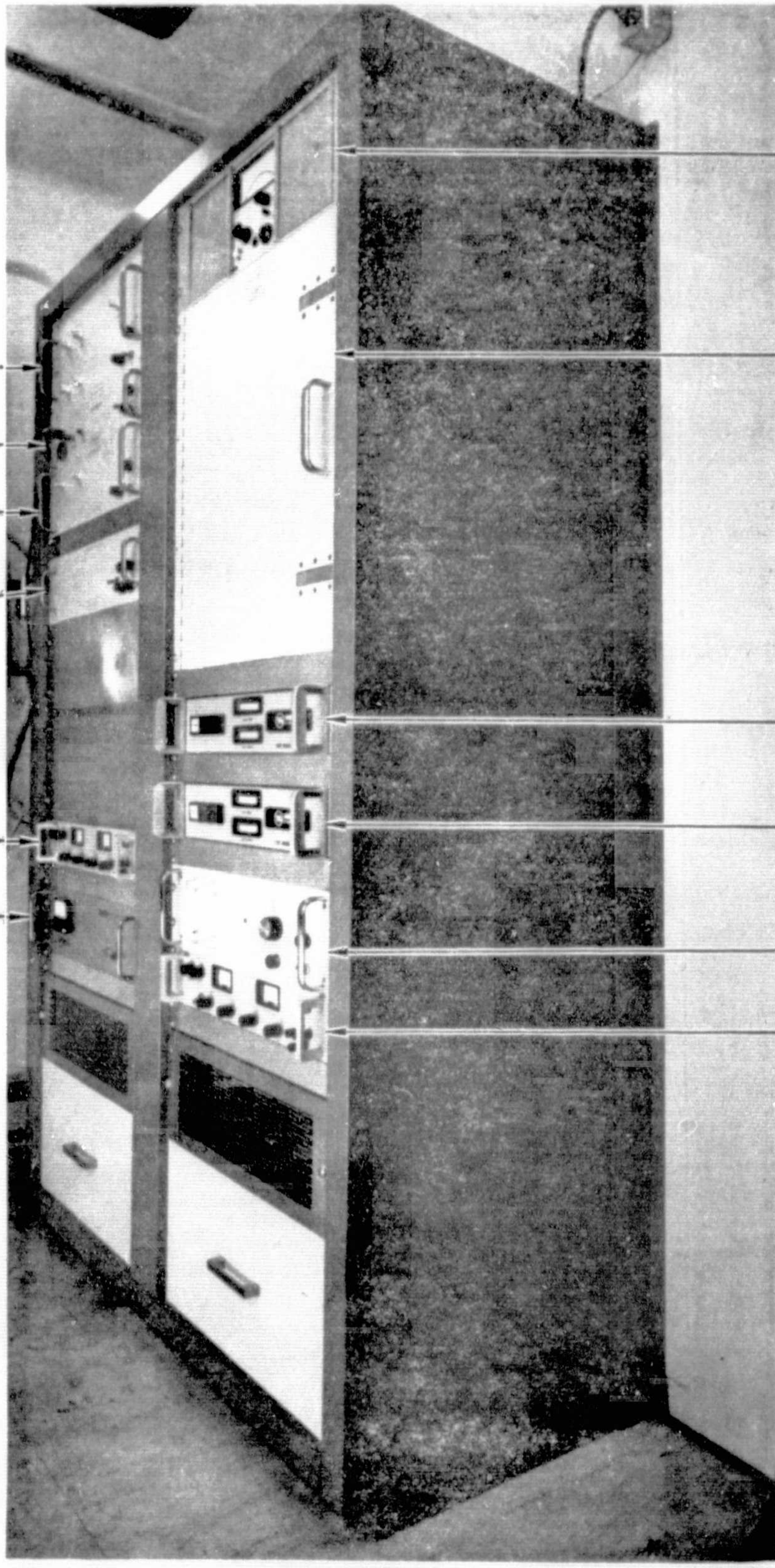


FIGURE 3-1. TARS ELECTRONIC EQUIPMENT RACK (PHOTO 4R24519)

are within normal operating ranges or conditions. This light will extinguish when the following conditions have occurred:

1) The shelter door had been opened.

2) The temperature on the interior had risen above or dropped below the set limits.

3) Main power to the shelter is disrupted.

Note

The alarm function must be manually reset after condition 1 or 2 has occurred. No reset function is required if power has been disrupted momentarily (condition 3).

3.3.2 Units Mounted Inside Shelter

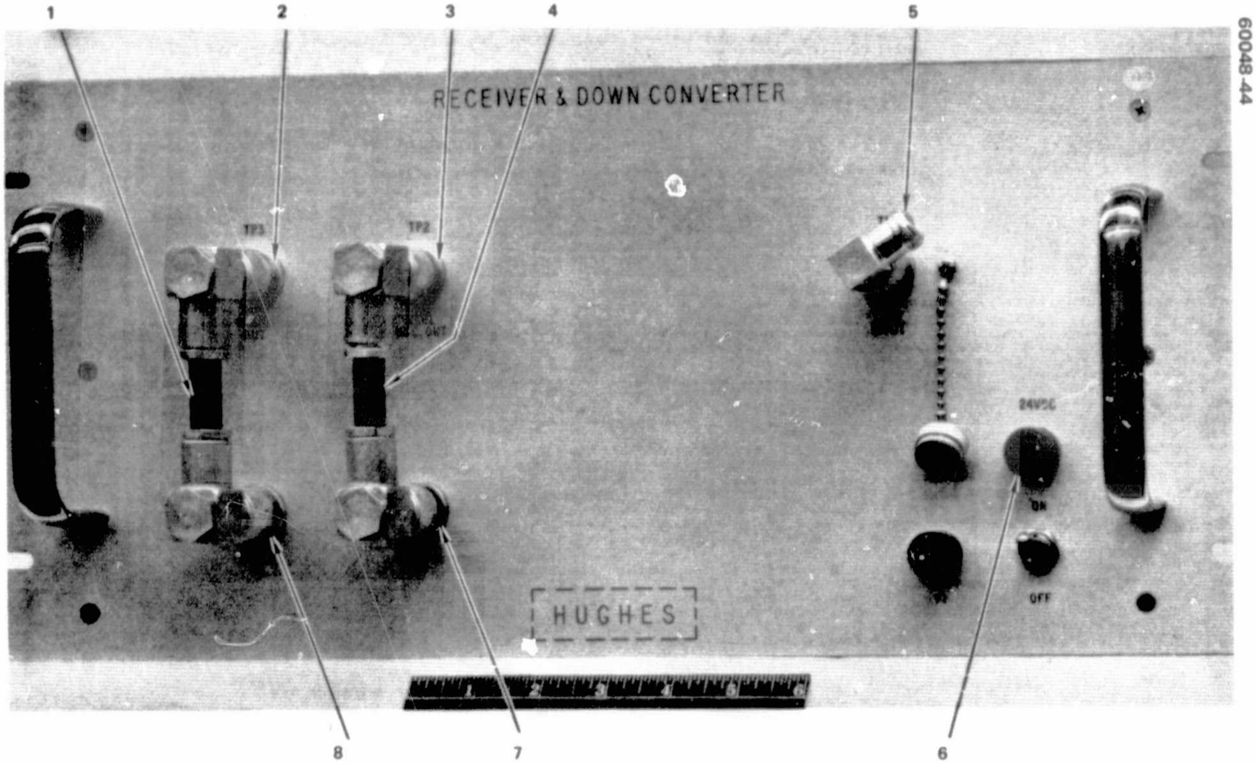
All units mounted in the shelter are located either on the bulkheads of the shelter or in either of two racks. (See Figures 1-4 and 3-1.) The location and function of the controls and indicators for the commercially available units are contained in the appropriate commercial handbook included in this series of manuals. The location and function of the units unique to the TARS terminal are presented in the following order:

Unit	Figure
Receiver/Downconverter Unit, Hughes P/N 3029312	3-2
Orderwire Unit, Hughes P/N 3029306	3-3
IF Amplifier Unit, Hughes P/N 3029313	3-4
Command Receiver Unit, Hughes P/N 3029308	3-5
Power Amplifier Unit, Hughes P/N 3029315	3-6
Upconverter Unit, Hughes P/N 3029314	3-7

The location and function of controls and indicators on units that are not listed above are included in the appropriate commerical handbook.

3.4 POWER TURN-ON

All electrical power to the units in the TARS terminal is controlled through a circuit breaker panel. (See Figure 1-4.) Other than setting all switches to ON, no special procedural instructions are required for applying power to any of the units in the TARS terminal. In those cases where sequential events are critical, interlocks are provided to ensure that no condition could exist that would prove harmful to the equipment with the application of main power to a unit.



PANEL ITEM	DESCRIPTION	FUNCTION
1	SHORTING CABLE	CONNECTS X80 MULTIPLIER TO MIXER
2	MULTI IN TP3 CONNECTOR	PROVIDES TEST POINT FOR SIGNAL INSERTION TO X80 MULTIPLIER
3	TRANSMITTAL OSCILLATOR OUT TP2 CONNECTOR	PROVIDES TEST POINT TO CHECK CRYSTAL OSCILLATOR OUTPUT
4	SHORTING CABLE	CONNECTS CRYSTAL OSCILLATOR TO X80 MULTIPLIER
5	TEST INPUT CONNECTOR	PROVIDES TEST POINT FOR RF SIGNAL INSERTION INTO RECEIVER AND DOWNCONVERTER UNIT
6	24 vdc POWER ON/OFF SWITCH INDICATOR AND FUSE	CONTROLS AND INDICATES AVAILABILITY OF POWER TO UNIT CIRCUITS
7	MULTI IN CONNECTOR	PROVIDES TEST POINT FOR INSERTION OF SIGNAL INTO X80 MULTIPLIER
8	MIXER IN CONNECTOR	PROVIDES TEST POINT FOR INSERTION OF SIGNAL INTO RF MIXER

FIGURE 3-2. RECEIVER AND DOWNCONVERTER UNIT (PHOTO 4R25715)

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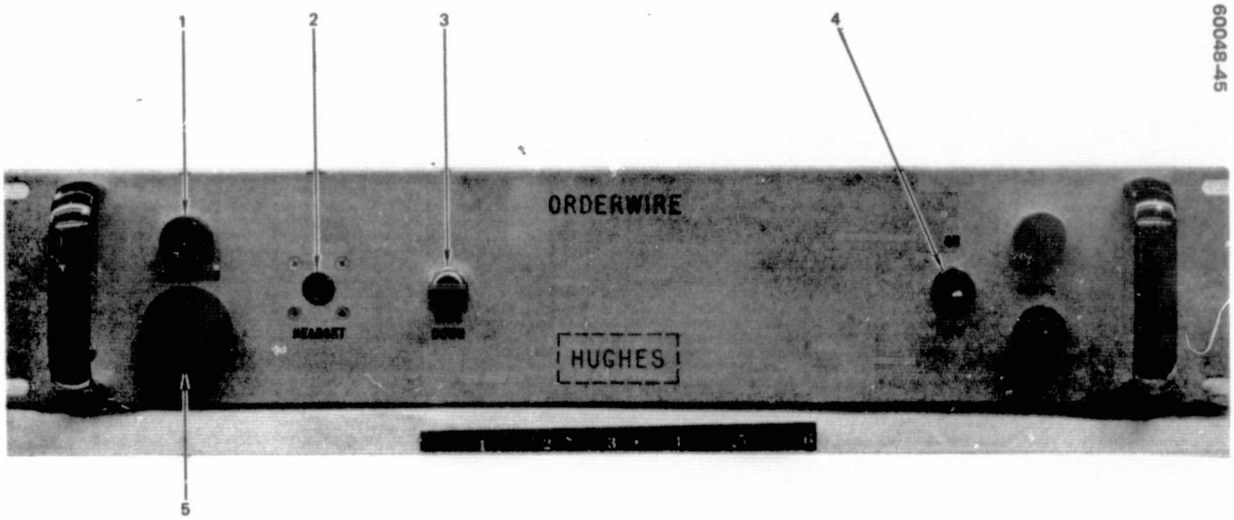
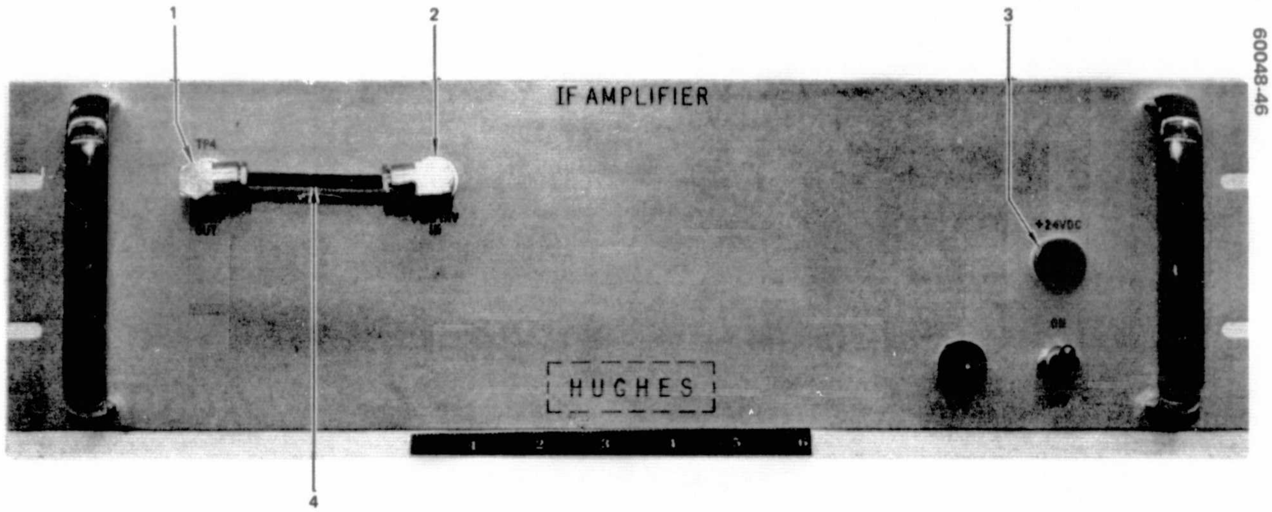


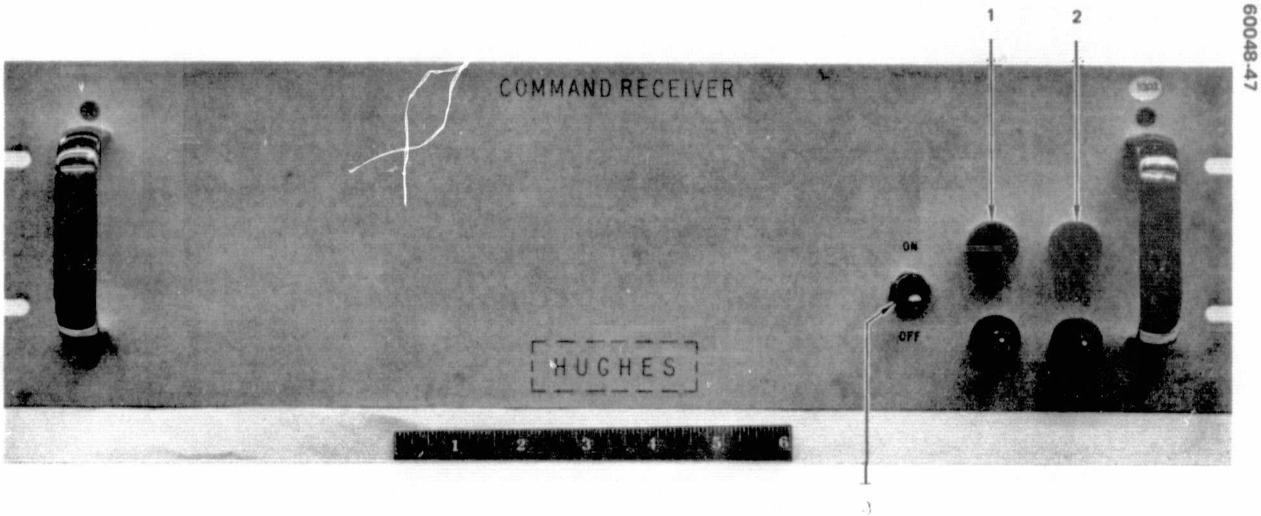
PANEL ITEM	DESCRIPTION	FUNCTION
1	SIGNALING LIGHT INDICATOR	INDICATES RECEIPT OF ORDERWIRE SIGNAL TONE
2	HEADSET CONNECTOR	PROVIDES INPUT FACILITY FOR TALK/LISTEN HEADSET
3	RING DOWN SWITCH	USED FOR ORDERWIRE SIGNALING BETWEEN TARS AND CDA
4	24 vdc POWER ON/OFF SWITCH INDICATOR AND FUSE	CONTROLS AND INDICATES THE APPLICATION OF 24 vdc POWER TO ORDERWIRE UNIT
5	SIGNALING BUZZER	PROVIDES AUDIBLE INDICATION OF RECEIPT OF ORDERWIRE SIGNAL TONE

FIGURE 3-3. ORDERWIRE UNIT (PHOTO 4R25719)



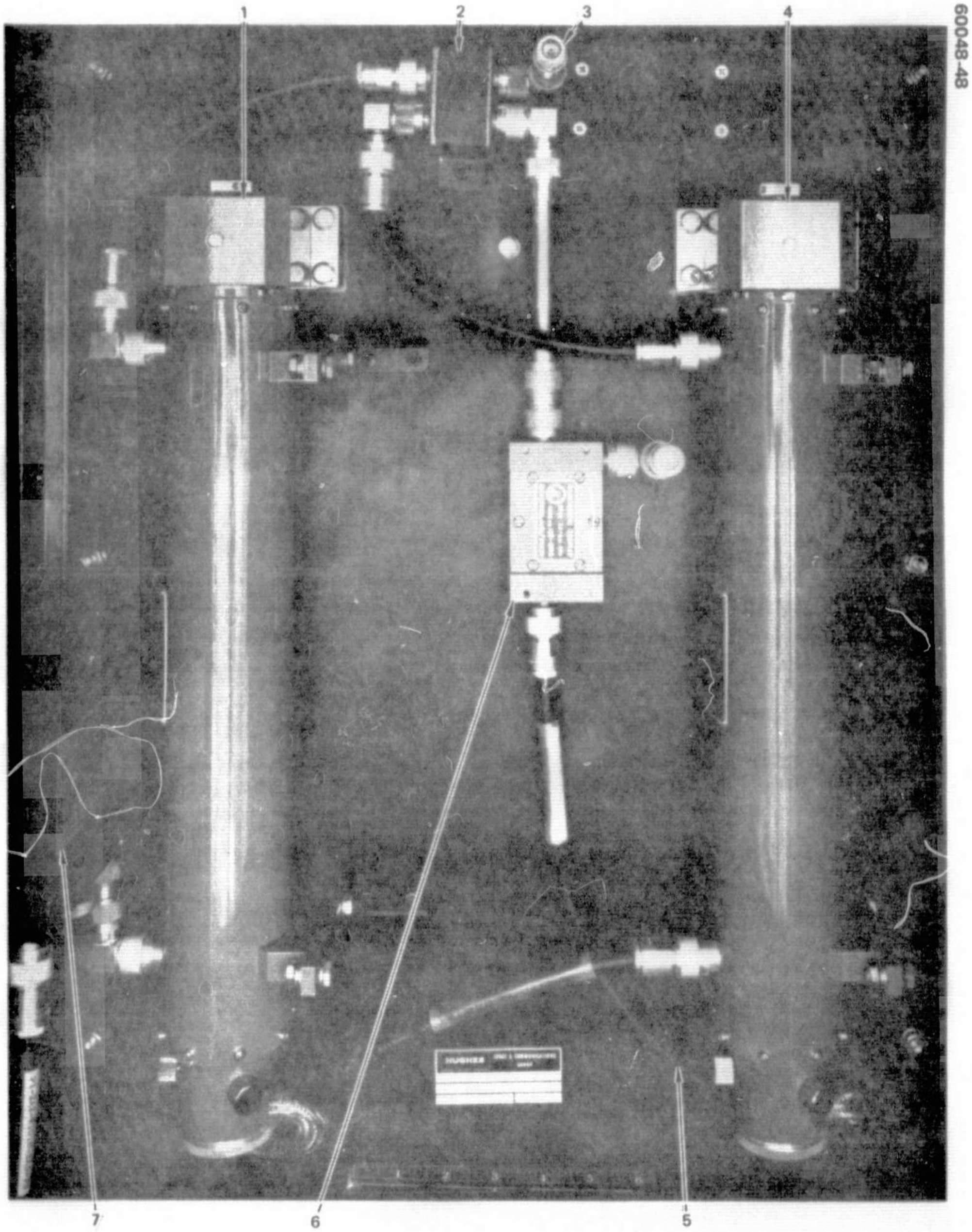
PANEL ITEM	DESCRIPTION	FUNCTION
1	IF AMPLIFIER OUT TP4 CONNECTOR	PROVIDES TEST POINT TO CHECK OUTPUT OF IF LIMITER/AMPLIFIER MODULE
2	POWER DIVIDER IN CONNECTOR	PROVIDES TEST POINT FOR SIGNAL INSERTION TO POWER SPLITTER
3	24 vdc POWER ON/OFF SWITCH, INDICATOR AND FUSE	CONTROLS AND INDICATES THE APPLICATION OF POWER TO THE IF AMPLIFIER UNIT
4	SHORTING CABLE	CONNECTS IF LIMITER/AMPLIFIER TO POWER SPLITTER

FIGURE 3-4. IF AMPLIFIER UNIT (PHOTO 4R25726)



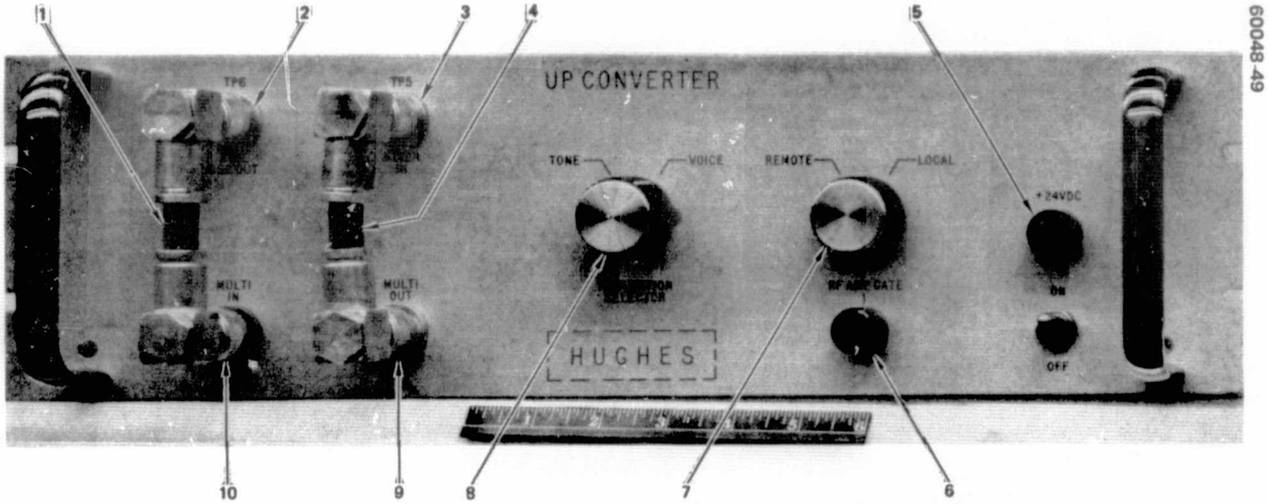
PANEL ITEM	DESCRIPTION	FUNCTION
1	24 vdc INDICATOR AND FUSE	INDICATES AVAILABILITY OF POWER TO 28 vdc CIRCUITS
2	115 vac 60 Hz INDICATOR AND FUSE	INDICATES AVAILABILITY OF POWER TO 115 vac CIRCUITS
3	ON/OFF SWITCH	CONTROLS APPLICATION OF POWER TO UNIT

FIGURE 3-5. COMMAND RECEIVER (PHOTO 4R25717)



1) VARIAN VYS2603A TWT
2) HYBRID
3) TEST CONNECTOR
4) VARIAN VYS2603A TWT
5) TRANSMITTER COAXIAL CABLE
6) DIRECTIONAL COUPLER
7) PHASE SHIFTER

FIGURE 3-6. POWER AMPLIFIER DETAILS (PHOTO 4R25728)



PANEL ITEM	DESCRIPTION	FUNCTION
1	SHORTING CABLE	CONNECTS CRYSTAL OSCILLATOR TO X100 MULTIPLIER
2	TRANSMITTAL OSCILLATOR OUT TP6 CONNECTOR	PROVIDES TEST POINT TO CHECK OSCILLATOR OUTPUT
3	MIXER IN TP5 CONNECTOR	PROVIDES TEST POINT FOR SIGNAL GENERATOR INPUT TO UPCONVERTER MIXER
4	SHORTING CABLE	CONNECTS OUTPUT OF X100 MULTIPLIER TO MIXER
5	ON/OFF SWITCH AND INDICATOR	CONTROLS THE APPLICATION OF 24 vdc POWER TO UNIT
6	RF AMPLIFIER GATE INDICATOR	INDICATES PRESENCE OF AMPLIFIER ENABLING SIGNAL
7	RF AMPLIFIER GATE INPUT SWITCH AND INDICATOR	SELECTS SOURCE OF 28 vdc GATE TO AMPLIFIER
	REMOTE	SELECTS CDA INITIATED COMMAND TONE FOR BASIS FOR GENERATING AMPLIFIER GATING SIGNAL
	LOCAL	APPLIES UNIT 28 vdc POWER TO ENABLE AMPLIFIER
8	MODULATOR SELECTOR SWITCH	SELECTS IF INPUT TO RF MIXER
	TONE	APPLIES OUTPUT OF IF AMPLIFIER UNIT TO UPCONVERTER CIRCUITS
	VOICE	APPLIES OUTPUT OF ORDERWIRE UNIT TO UPCONVERTER CIRCUITS
9	MULTI OUT CONNECTOR	PROVIDES TEST POINT TO CHECK X100 MULTIPLIER OUTPUT
10	MULTI IN CONNECTOR	PROVIDES TEST POINT TO INSERT EXTERNAL SIGNAL SOURCE INTO X100 MULTIPLIER

FIGURE 3-7. UPCONVERTER UNIT (PHOTO 4R25713)

3.5 SYSTEM OPERATION

In general, the TARS terminal equipment can be configured for two modes of operation: ranging and orderwire. The procedures for operation in these modes are contained in the following paragraphs.

3.5.1 Ranging Operations

To configure the TARS equipment for ranging operations, perform the following:

1) On the upconverter unit, set modulation selector switch to TONE.

2) Set RF Amp Gate switch to REMOTE. The RF Amp Gate indicator will light each time the TARS transmit function is enabled by a signal transmitted from the CDA and will extinguish on receipt of a subsequent signal to indicate that the transmit function is disabled.

3.5.2 Orderwire Operations

To configure the TARS equipment for orderwire operations, perform the following:

1) On the upconverter unit, set Modulation Selector switch to VOICE.

2) Set RF Amp Gate switch to LOCAL. The RF Amp Gate lamp lights to indicate that the transmitter function is enabled.

3) On the orderwire panel, ensure that power is applied to unit and headset is patched correctly.

4) Momentarily press Ring Down switch to signal CDA terminal. Set Headset Microphone switch to ON to talk and to OFF to listen.

3.6 POWER TURN-OFF

No special procedural instructions are required to turn off power to any of the units in the TARS terminal.

4. THEORY OF OPERATION

4.1 INTRODUCTION

This section provides a concise description of the principles of operation of the Turn-Around Ranging Station (TARS) as a system and supplies the operating principles of units that are peculiar to the terminal. The principles of operation of units that are commercially available can be located in the appropriate document within this series of manuals.

The order in which the information is presented in this section is as follows:

1) Overall Functional Description — Paragraph 4.2

2) Unit Operation Description — Paragraph 4.3

Information pertaining to the command and data handling assembly equipment may be found in Volume I of this series of manuals.

4.2 OVERALL FUNCTIONAL DESCRIPTION

The basic function of each of the TARS terminals in the Trilateration Range and Range Rate (TRRR) System is to retransmit all signals received through the SMS from the master station Command and Data Acquisition (CDA) station. To perform this function, each of the TARS is equipped with a transponder section which consists of a receive antenna, a low noise amplifier, a command receiver, a downconverter, an upconverter, a power amplifier, and a transmit antenna. In addition to the transponder section, each of the TARS terminals also contains an orderwire system to enable data communications between the CDA and the TARS terminals. (See Figure 4-1.)

With the exception of the antennas and their associated feeds, all operational equipment in the TARS terminal is mounted in two racks which are located in the environmentally controlled interior of an insulated fiberglass shelter. The receive and transmit antennas are mounted on a common horizontal tube on the exterior surface of the shelter. The feeds associated

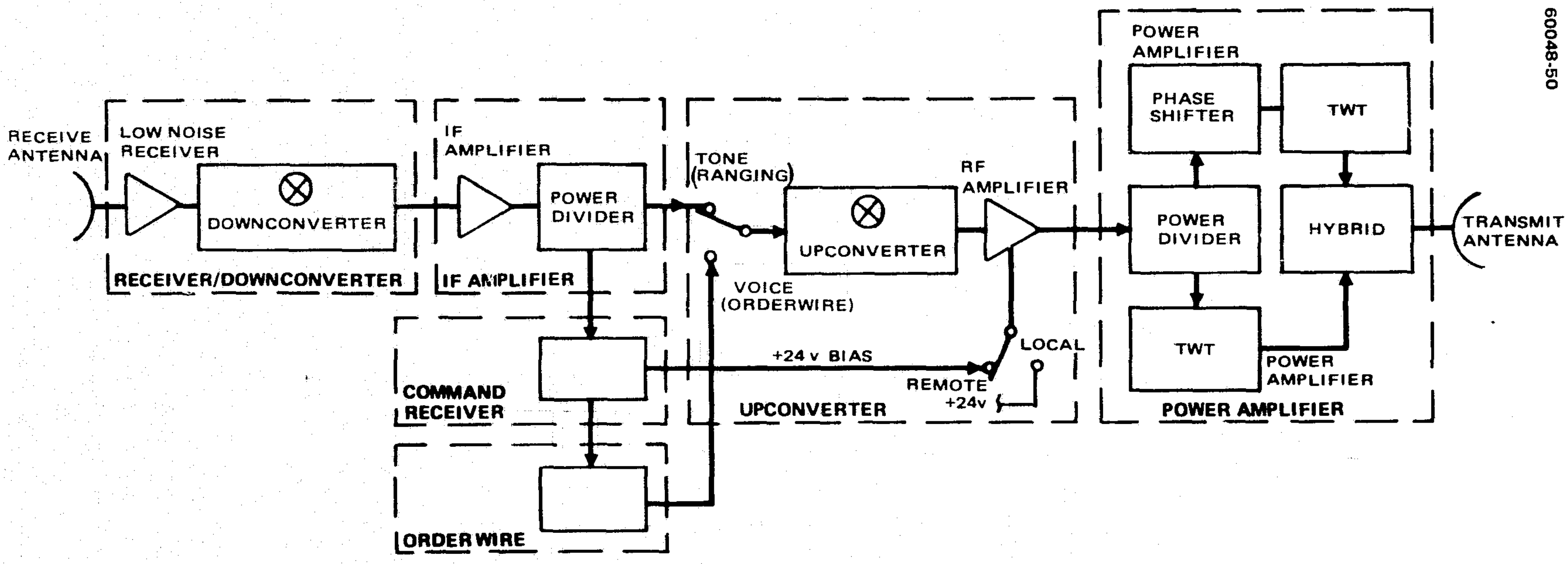


FIGURE 4-1. TARS TERMINAL, FUNCTIONAL SIGNAL FLOW

with each of the antennas are linear polarization feeds with the angle adjusted by manually positioning the feed from the rear of each reflector.

4.2.1 Receive System

The transponding function of the TARS commences with the generation and transmission of an audio frequency command tone from the CDA station. This tone, which is different for each TARS terminal, is upconverted and transmitted from the NASA STADAN Station at Wallops Island to the SMS spacecraft at an RF frequency of 2026.000 MHz. This signal is then downconverted and retransmitted by the spacecraft at a frequency of 1684.000 MHz. This signal is received by TARS 1 and 2 at the receive antenna and feed system.

4.2.2 Receiver, Downconverter, and IF Amplifier Functions

The received signal is transmitted through a coaxial cable from the receive antenna feed to the receiver and downconverter unit, where it is amplified and downconverted to a 70 MHz IF signal. The IF signal is amplified and applied to a power divider in the IF amplifier unit. One output of the power divider is applied to the command receiver, while the remaining output is applied through a Tone/Voice switch to a mixer circuit in the upconverter unit which configures the signal for retransmission to the SMS.

Signal processing in the command, receive unit is provided in paragraph 4.2.3; signal processing in the upconverter unit is provided in paragraph 4.2.5.

4.2.3 Command Receiver Function

Three audio tones within the 70 MHz IF band are detected in the discriminator circuit and transmitted to three functions in the TARS: the command tone receiver, the orderwire tone receiver, and the orderwire telephone receiver. (See Table 1-5.)

The function of the command tone receiver is to bias the TARS transmitter section to retransmit the ranging tones that are received from the CDA through the SMS. The TARS transmitter section is mechanized to keep the TWTs operating at all times; the TARS transmission lines, however, are controlled by gating the RF amplifier in the upconverter unit to operate only during the periods when transmission from the TARS terminal is desired. The RF amplifier gating signal is controlled by an alternate mode switching relay which is controlled by the output of the command tone receiver.

During the remote (transponder) mode, this system is mechanized to operate in the following manner. The CDA transmits a command tone which gates the RF amplifier into operation. The ranging tones are transmitted by the CDA, received, downconverted to IF, upconverted to RF, and retransmitted by the TARS. At the completion of the ranging sequence, a command tone is again transmitted by the CDA. When received by the TARS, this tone biases the RF amplifier to cutoff, thus disabling the transmit function. The

transponder function of the TARS will remain disabled until the receipt of a subsequent command tone even though RF signals are received and processed. This function is required to ensure receipt of orderwire ringing tones during transistory (ringing to orderwire) periods.

It should be noted that the command tone receiver in each of the TARS is set to a different frequency to ensure isolation during ranging functions. (See Table 1-5.)

4.2.4 Orderwire Function

The function of the orderwire tone receiver is to detect the orderwire ringing signal which, upon detection, actuates a relay to operate a light and a buzzer circuit.

All audio frequencies are routed directly from the discriminator in the command receiver to the telephone headset which is used for voice communication and data transmittal.

In addition to the receiving function, the orderwire unit contains a voice frequency telephone transmitter and a ringing tone generator that is switch-controlled. The output of each of these functions is applied to a 70 MHz voltage-controlled oscillator prior to application to the TARS upconverter unit.

4.2.5 Upconverter Function and Transmit Section

The input signal to the upconverter unit is controlled by a Tone/Voice switch on the front panel of the unit. When set to TONE, the Ranging Tone signal from the IF amplifier unit is applied to a mixer which converts the IF signal to the proper S band frequency. (See Table 1-4.) The S band signal is then amplified to 20 dBm in the upconverter amplifier and then amplified to 45 dBm by two parallel connected TWTs prior to transmission through the transmit antenna to the SMS.

Note that a Remote/Local switch is provided on the front panel of the upconverter unit. When set to REMOTE, the RF amplifier is biased to operate on receipt of alternate signals from the command receiver; when set to LOCAL, biasing is supplied directly from the terminal 24 volt power source.

4.2.6 Alarm Function

A flashing alarm light on the shelter provides visual status of the following functions:

1) High internal temperature (set in °F)

2) Low internal temperature (set in °F)

3) Unauthorized entry into shelter

4) Main power failure

Note

It should be noted that the Alarm Light is a negative logic function. While the light is flashing, all functions are in a normal operating configuration; when the light is extinguished, one or more of the above abnormal functions have occurred.

Power to the flashing light is applied through the normally closed contacts of relay K2 located in the alarm sensor panel. (See Figures 1-4 and 4-2.) Relay K2 is energized when the internal temperature of the shelter goes above or below the limits set on the temperature alarm sensors or the shelter door has been opened. When these conditions have existed for any period of time (above a very few microseconds for relay reaction time), relay K2 actuates and remains actuated through its own contacts, which are now closed, and the normally closed contacts of relay K1. In addition to supplying a holding voltage to the solenoid, the closed contacts of K2 also provide a voltage to an alarm reset function.

The alarm reset function consists of relay K2 and an Alarm Reset switch. Assume that an alarm function has occurred which actuates relay K2. Relay K2 remains energized through the normally closed contacts of K1. When the Alarm Reset switch is momentarily pressed, relay K1 is energized, removing the holding voltage to relays K1 and K2. When the Alarm Reset switch is released, relays K1 and K2 remain deenergized unless the alarm function persists or a new alarm function is experienced.

Because of the mechanization of the alarm function, the following technique must be employed when leaving the shelter. When exiting, the door is opened and left opened. This action energizes relay K2 to extinguish the Alarm Light. The Alarm Reset switch is pressed and released. At this time, both relays K1 and K2 are energized, relay K 2 through the contacts of the Door Open switch and relay K1 through the contacts of the Door Open switch and its own actuated contacts. When the door of the shelter is closed, both relays are deactuated by the lack of a supply voltage and the Alarm Light is provided operating power through the normally closed contacts of relay K2.

Note that a reset function is not required when a power failure occurs temporarily. Since no sequential application of power is required for any of the units of the TARS terminal, no unique power failure sensor is provided.

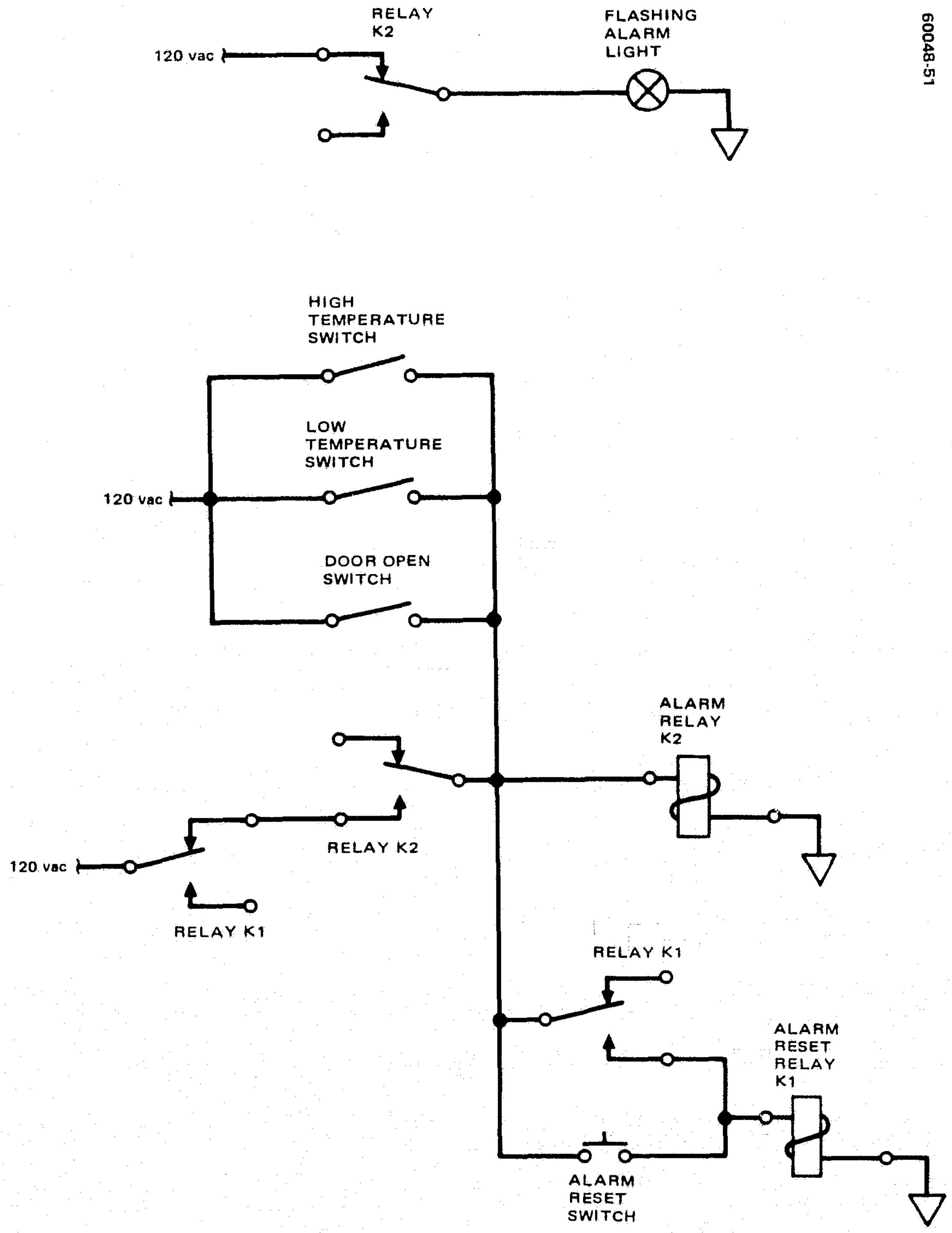


FIGURE 4-2. ALARM FUNCTION SIMPLIFIED SCHEMATIC

4.3 UNIT OPERATION DESCRIPTION

The theory of operation of each of the units that are unique to the TARS terminal is provided in the following paragraphs in the following order:

1) Receiver and Downconverter Unit — Paragraph 4.3.1

2) IF Amplifier — Paragraph 4.3.2

3) Upconverter Unit — Paragraph 4.3.3

4) Power Amplifier Unit — Paragraph 4.3.4

5) Command Receiver Unit — Paragraph 4.3.5

6) Orderwire Unit — Paragraph 4.3.6

The theory of operation of units not peculiar to the TARS may be found in the commercial handbooks associated with this series of manuals or in Volume I.

4.3.1 Receiver and Downconverter Unit

The receiver and downconverter unit is designed to amplify and convert to an IF level, the S band frequency signal received from the CDA terminal through the SMS. (See Figure 4-3.) The S band signal is routed from the receive antenna feed to RF input connector, J2, through a coaxial cable. From J2 the signal is applied through directional coupler DC1 and filter FL1 to amplifier AR1 where the signal is amplified prior to application through bandpass filter FL2 to mixer amplifier M1 where the signal is downconverted to 70 MHz IF and made available at IF output connector J3.

Frequency downconversion is accomplished by mixing the RF input of 1684.0 MHz with a local oscillator frequency of 1754 MHz which is derived by detecting the eightieth harmonic of a phase-locked signal source X1 which is excited by crystal oscillator Y1 which has an output frequency of 21.925 MHz. Attenuator AT1 is used to limit the local oscillator signal input to the mixer.

Test points TP 1 through 3 are provided to enable isolation of the various functions within the unit and to enable signal insertion or signal sampling, as required, for fault isolation.

4.3.2 IF Amplifier Unit

The IF amplifier unit is designed to filter, amplify, and provide the 70 MHz IF signal with the characteristics that are required for proper ranging operations. (See Figure 4-4.) The IF signal is applied to the amplifier unit through IF input connector J2 to filter assembly FL1 which, in addition to attenuating all signals outside the IF frequency range, provides the signal with the correct response characteristics. The signal is then amplified and

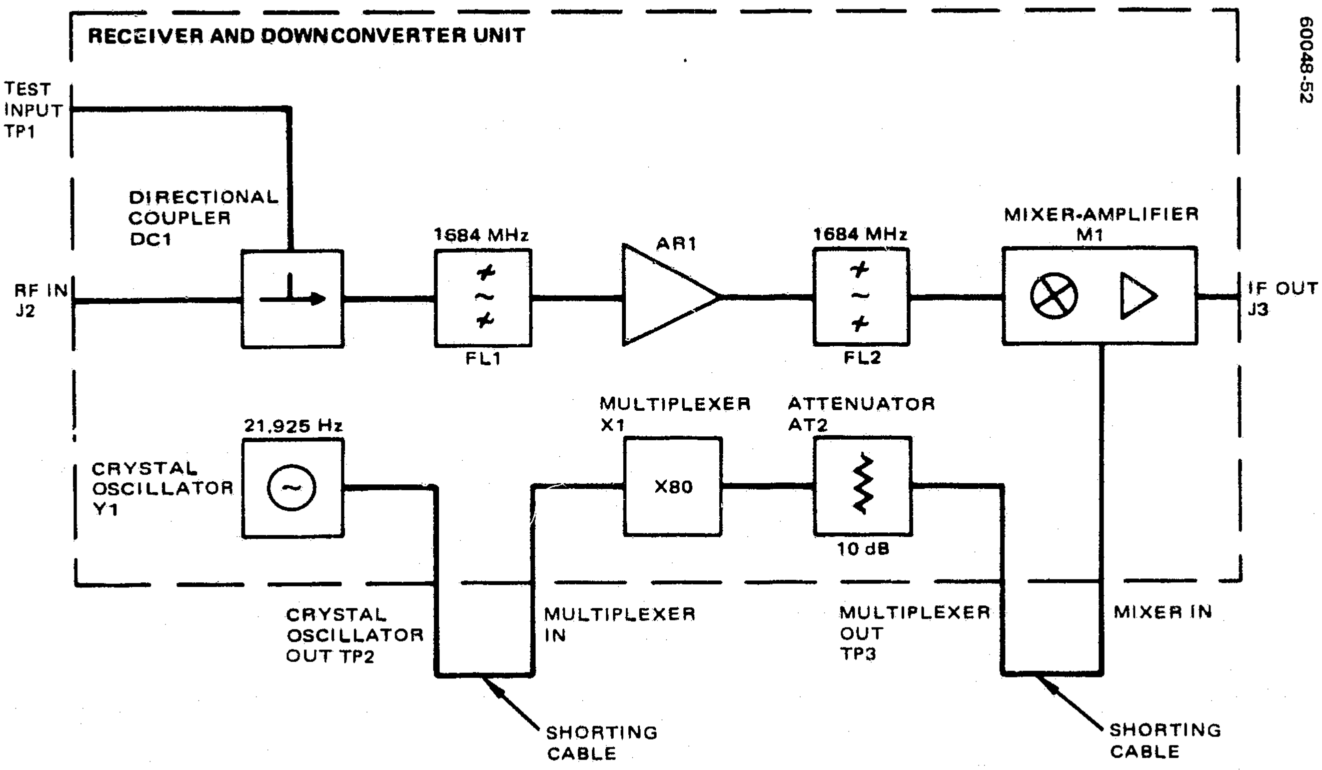


FIGURE 4-3. RECEIVER AND DOWNCONVERTER UNIT SIMPLIFIED SCHEMATIC

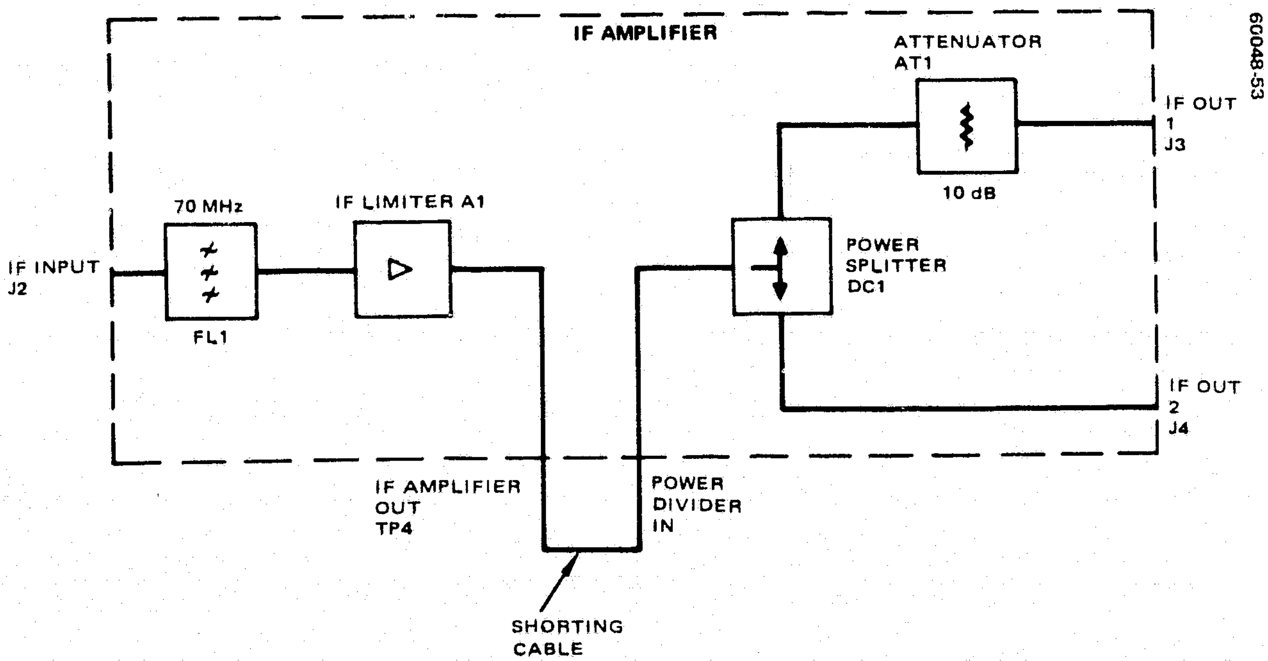


FIGURE 4-4. IF AMPLIFIER UNIT SIMPLIFIED SCHEMATIC

limited in assembly A1 and transmitted to power splitter DC1. The function of the power splitter is to provide two output functions from the amplifier unit. One output, available at connector J3 after attenuation by AT1, is transmitted directly to the upconverter unit in the TARS; the remaining output is sent directly to connector J4 for transmission to the command receiver unit.

Test point 4 is provided to enable isolation of the various functions within the unit and to enable signal insertion or signal sampling, as required, for fault isolation.

4.3.3 Upconverter Unit

The function of the upconverter unit is to accept either of two signals in the IF frequency range, upconvert the signal to an S band frequency limit then amplify the signal prior to further amplification in the power amplifier unit. (See Figure 4-5.) In addition to the above, the transmitting function of the TARS terminal is enabled or disabled in accordance with the state of transistor amplifier A3 in the driver amplifier module. This is required as the power amplifiers in the TARS are in the operating mode at all times.

The Voice and Tone inputs to the upconverter unit are applied to connectors J3 and J4, respectively, at a 70 MHz IF frequency. The signal to be processed is determined by the position of Voice/Tone Coax switch S3 whose output is applied through mixer A1, where the signal is upconverted to 2030.2 MHz for TARS 1 and 2032.2 MHz for TARS 2, through limiter A2 and amplifier A3 prior to application to power splitter DC1. The RF outputs of power splitter DC1 are available at connectors J5 and J6 for connection to each of two TWTs connected in parallel in the power amplifier unit.

The input to the power amplifier unit is controlled by the state of transistor amplifier A3 in the upconverter unit. The transistor amplifier is enabled only with the application of +24 volts to the amplifier circuits. This voltage is supplied from either of two sources as determined by the position of the Local/Remote switch S2 in the upconverter unit. When REMOTE is selected, the command receiver unit supplies +24 volts in response to command On/Off tones originated at the CDA terminal and transmitted to the TARS through the SMS; when LOCAL is selected, the +24 volts is applied to the transistor amplifier directly from the terminal 24 voltage supply. Thus, when switch S2 is set to LOCAL and switch S3 is set to VOICE, the upconverter unit is configured for orderwire operation; when switch S2 is set to REMOTE and switch S3 is set to TONE, the upconverter unit is configured for ranging operations.

The frequency conversion from IF to RF is accomplished by mixing the IF signal of 70 MHz with the one hundredth harmonic of a phase-locked signal source X1 which is excited by a crystal oscillator Y1. The output of the crystal oscillator is 21.002 MHz for TARS 1 and 21.022 for TARS 2. The difference in frequency is to ensure a 2 MHz guard band in the transmission frequencies of each of the TARS.

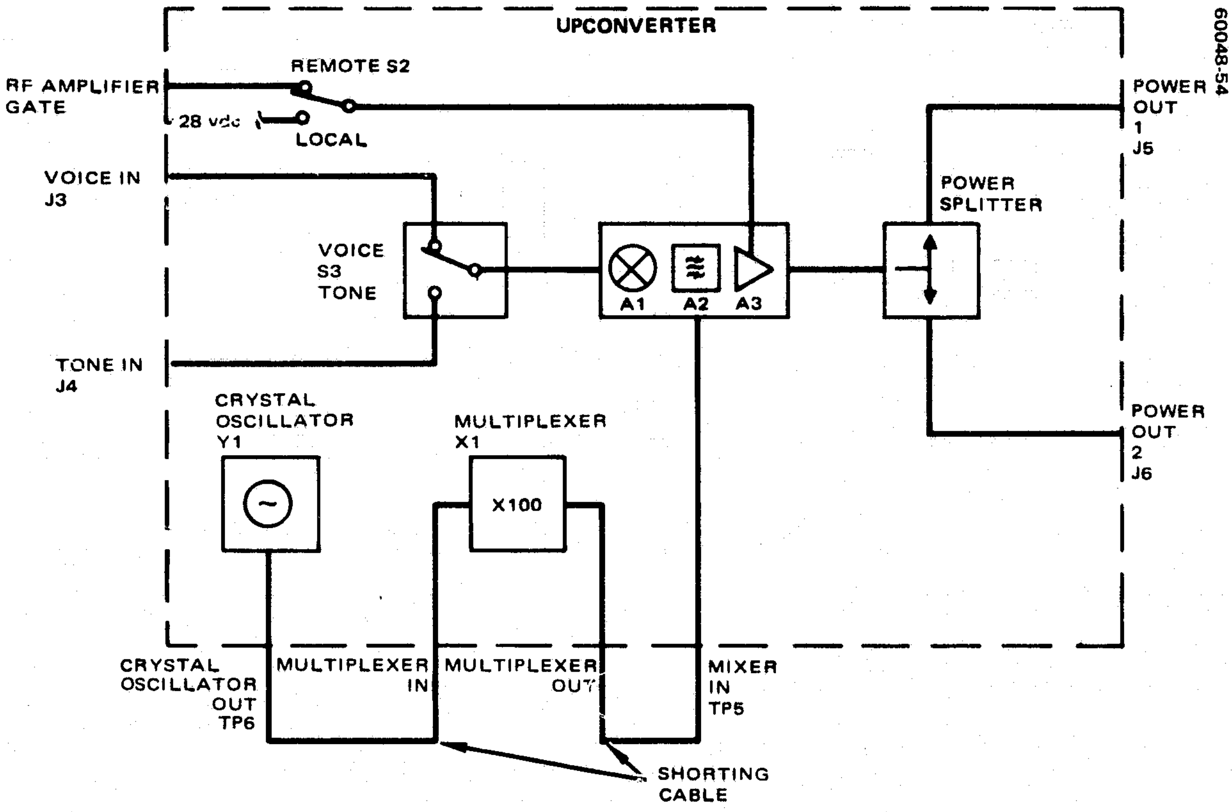


FIGURE 4-5. UPCONVERTER UNIT SIMPLIFIED SCHEMATIC

4.3.4 Power Amplifier Unit

The function of the power amplifier unit is to amplify the output of the upconverter unit to a signal level of 46 dBm. (See Figure 4-6.) This is accomplished by paralleling two Varian model VYS2603A1 traveling-wave tubes, each powered by its own power supply.

One of the outputs of the upconverter unit is applied directly to TWT 2 for amplification. The input to TWT 1, however, is applied through a phase shifter prior to application to the amplifier. The function of the phase shifter is to enable the manual removal of any phase differences between each of the two input signals that may have been generated in connecting the upconverter unit to the power amplifier unit. After amplification in each of the TWTs, the signals are summed in the hybrid network, and applied through a directional coupler to the RF output connector for connection to the transmit antenna.

4.3.5 Command Receiver Unit

The function of the command receiver is to detect command tones and orderwire frequencies from the received 70 MHz IF and to enable or disable the RF amplifier in the upconverter unit in accordance with the operational requirements. (See Figure 4-7.)

The IF input to the command receiver is amplified at connector J3 and through filter FL1 prior to detection in the discriminator and limiter module D1S1. The audio frequencies are applied to audio amplifier AR1 and tone receiver RX1 and made available for connection to the orderwire unit at connector J4. When the command tone frequency is detected for a minimum required time period, the command tone receiver generates an operating voltage to actuate sensing relay K1 which, in turn, applies a 24 volt ac actuating voltage to operate latch relay K2. Relay K2 is mechanized such that the receipt of an actuating voltage causes the relay to select one set of contacts. The relay will maintain that set of contacts even after the actuating voltage is removed, until the receipt of a subsequent actuating voltage which causes the alternate set of contacts to be selected. The selection of one set of contacts applies a 24 volt dc gating voltage to the RF amplifier in the upconverter unit through connector J5. Thus, when one command tone is received, a 24 volt dc gating signal is generated to enable the TARS transmission section during the transponding function of the ranging operation; when the second command tone is detected, the gating signal is removed and the transmitter section is disabled. In this manner, the transponding function is enabled only during ranging operations between the transmission of command tones.

It should be noted that although the frequency of the command tones is within the spectrum of the voice frequency in the orderwire function, the time delay in the system and the operating pulse duration required to actuate the sensing relay is sufficient to guard against the inadvertent actuation of latch relay K2.

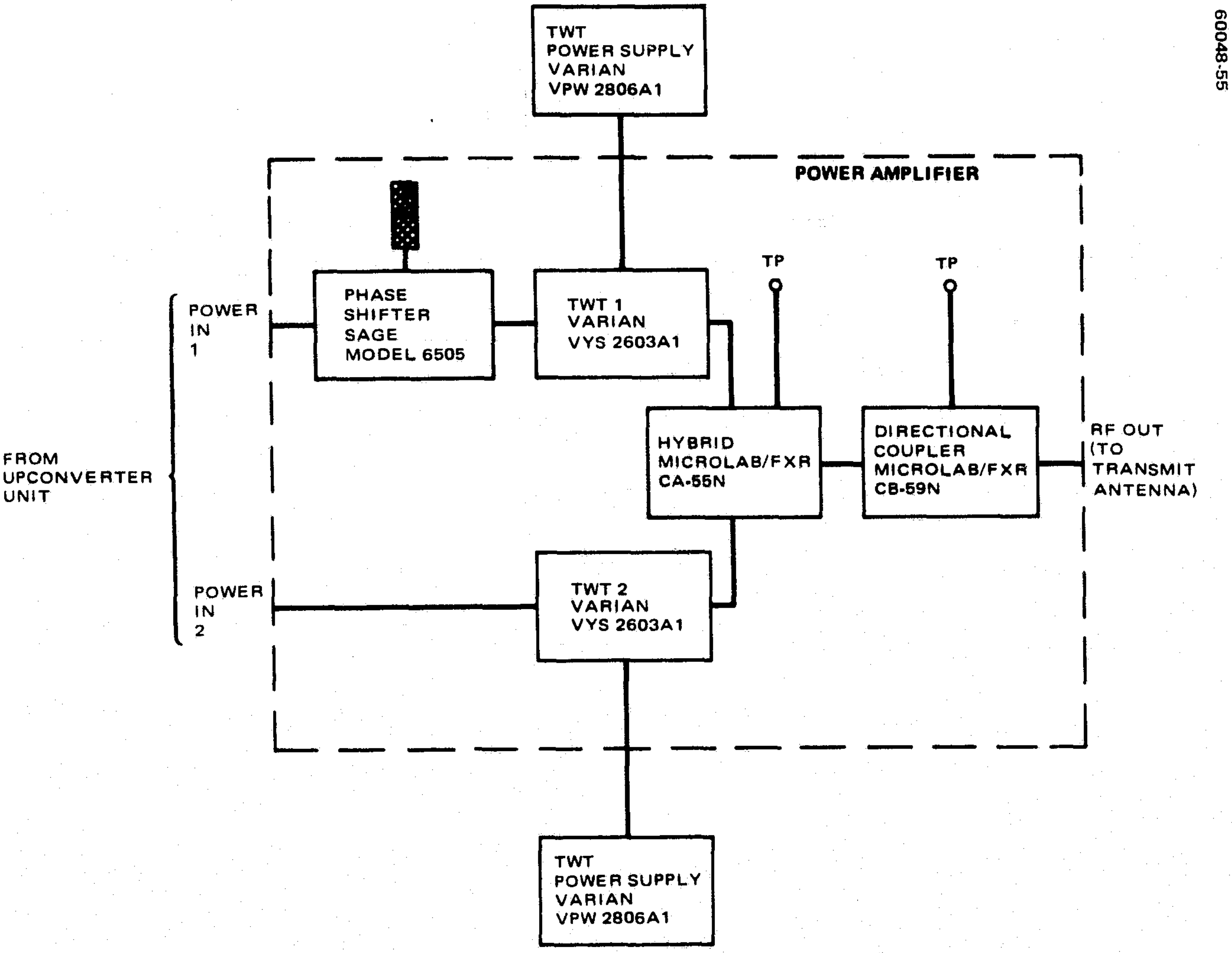


FIGURE 4-6. POWER AMPLIFIER UNIT SIMPLIFIED SCHEMATIC

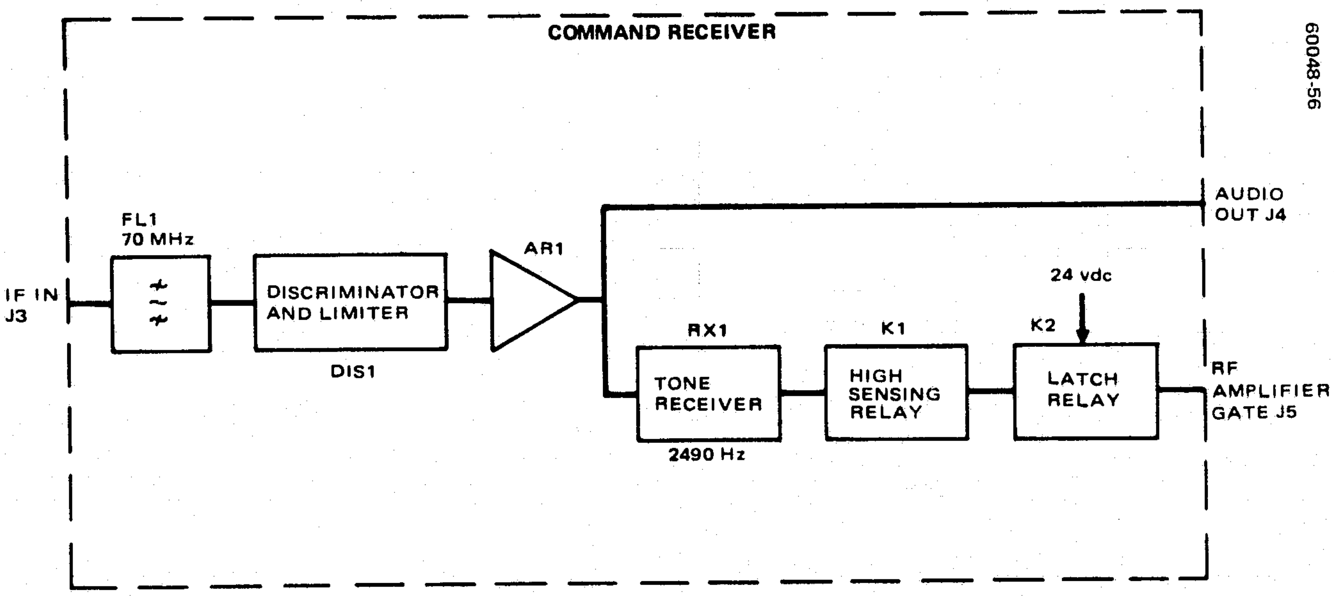


FIGURE 4-7. COMMAND RECEIVER UNIT SIMPLIFIED SCHEMATIC

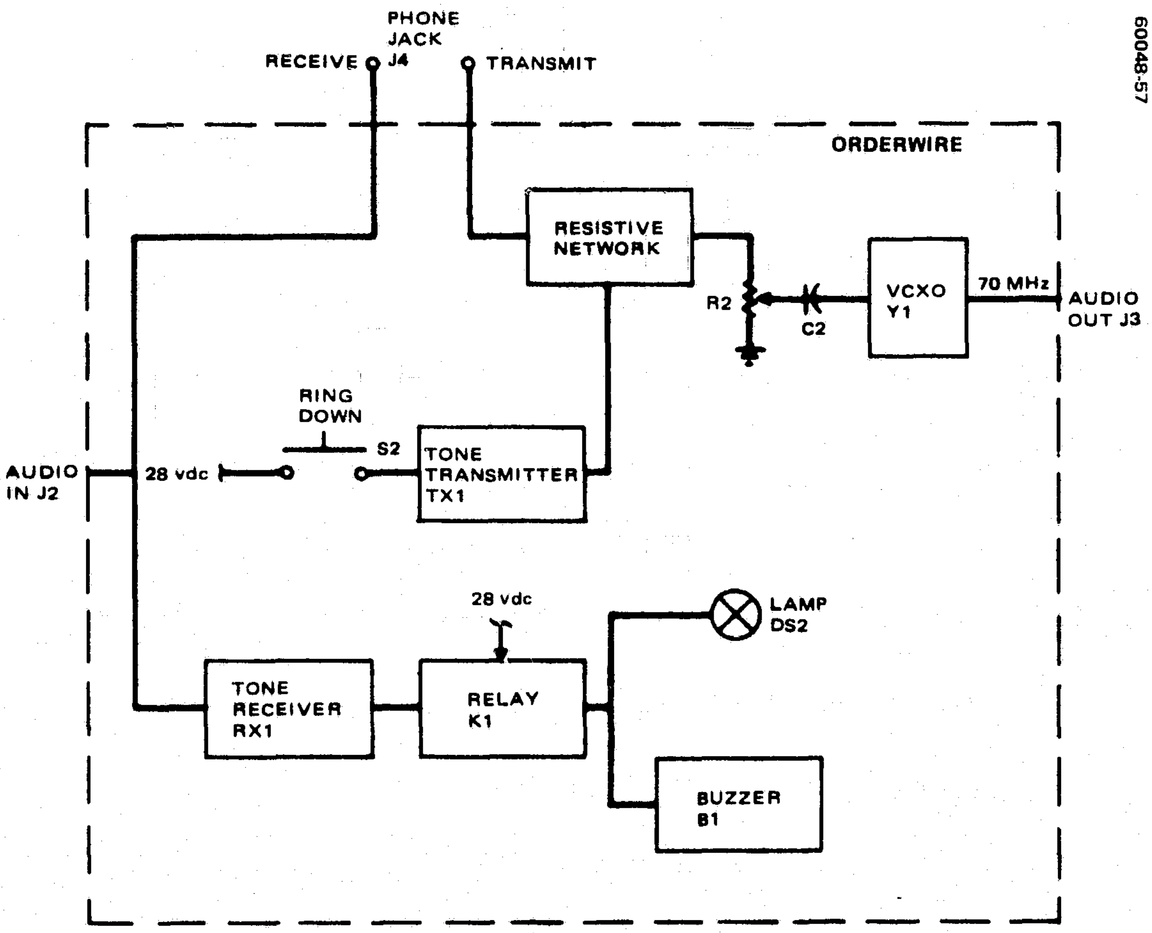


FIGURE 4-8. ORDERWIRE UNIT SIMPLIFIED SCHEMATIC

Note

It should also be noted that the command tone for each of the TARS is different to ensure isolation between each of the systems. The command tone for TARS 1 is 2940 Hz, while the command tone for TARS 2 is 3180 Hz. (See Table 1-3.)

As the discriminator and limiter module and the audio amplifier require a source of positive and negative 12 volts dc, a power supply is incorporated in the command receiver to provide this power in addition to the 28 volts dc required by other functions in the unit. This power supply is provided operating power from the terminal 115 volt ac power source.

4.3.6 Orderwire Unit

The function of the orderwire unit is to provide a means of voice communication and signaling between the TARS and the CDA to ensure coordination during equipment inspection periods. (See Figure 4-8.) The audio input to the orderwire unit is derived from the discriminator and limiter module in the command receiver unit which detects the audio frequencies from the 70 MHz IF signal in the receive section of the TARS. The audio signal is applied from the audio input connector J2 to the tone receiver module RX1 where the 4525 Hz ringing signal is detected. When this signal is detected, relay K1 energizes to energize signal light DS2 and sound buzzer B1. In addition to the above, the audio signal is applied to a headset on the orderwire panel through phone jack J4 to the headset receive terminal. The talk terminal is resistive coupled with the output of tone generator TX1 to VCXO Y1 through capacitor C2. Voltage-controlled crystal oscillator Y1 provides the conversion of the orderwire audio frequencies to the terminal 70 MHz IF signal before coupling to the upconverter unit through audio output connector J3.

The operation of tone transmitter TX1 is controlled by ringdown switch S2 which controls the application of 24 volt dc power to the unit. When switch S2 is pressed, the 4525 Hz signal is applied to the voltage-controlled crystal oscillator which converts this signal to IF frequency levels in the same manner as that used to convert the voice frequencies.

APPENDIX. TARS PERIODIC MAINTENANCE PROCEDURE

STATION DATA

Date: ______________________________

Location: ______________________________

Range System No. ____________ TARS No. ________ S/N ________

Command Frequency: ______________________________ Hz

Spacecraft Location ______________________________ Longitude

Azimuth Angle to Spacecraft: ______________________________

Elevation Angle to Spacecraft: ______________________________

Polang: ______________________________ (from vertical)

A. 1 PRELIMINARY CHECKS

Prior to operational measurements, certain visual observations should be made to determine maintenance required to store and sustain station hardware for the duration of the next operating period. It is expected that additional maintenance will be required at locations having a salt-air environment.

A. 1. 1 Antenna Structure

1) Paint - Clean rust areas with a wire brush. Paint with a rustoleum primer and finish with paint, Federal Standard ______.

2) Electrical Connections - Remove coax connections at both antennas and at top of shelter. Inspect connectors for corrosion. Clean or replace as required. Loosen clamps that secure feeds at base of feed assemblies. Note that feeds are free to rotate. Lubricate with Darv Corning DC4 as required. After reconnecting coax cables, cover connections with a silicon rubber compound.

A. 1. 2 Air Conditioners

1) Cleaning - Wash air filters with soap and water. Note that main assembly does not contain excessive foreign matter.

2) Operating Checks - Manually operate both air conditioners and note that normal air cooling is supplied by both. When in doubt, have air conditioners recharged. Check automatic control of both units from the thermostat.

A. 2 OPERATIONAL ALIGNMENTS AND MEASUREMENTS

A. 2. 1 Power Supplies

1) Measure voltages on the 24 Vdc power supplies. Adjust as required.

2) Check ac line regulator and adjust as required.

A. 2. 2 Station Warning Light

1) Check that unauthorized entry interlock is functioning.

2) Check that over- and undertemperature interlock is functioning.

3) Adjust temperature controls so that lower air conditioner will cycle on at 70°F. Set controls for upper air conditioner turn-on at 74°F.

A. 2. 3 TWT Alignment and Power Output Measurement

1) TWT Alignments

WARNING

APPLYING POWER TO UNTERMINATED TWT'S
WILL DESTROY ONE OR BOTH UNITS.

a) Place rotary switch on upconverter to VOICE position.

b) Apply power to TWT 1 by switching on upper power supply. TWT 2 should be off. Connect power meter to TP8.

c) Adjust beam current for 67.5 mA as monitored on power supply meter.

d) Adjust helix current for maximum power as monitored on power meter.

e) At base of TWT, adjust three mounting alignment screws for minimum helix current.

f) Vary GRID voltage adjustment on power supply to obtain minimum helix current on power supply meter. Record power at TP8 (approximately -8.0 dBm). ____________ dBm

g) Repeat above procedure for TWT 2. Check that power at TP8 is same as that recorded in previous step. If necessary, adjust beam current to equalize two power readings.

h) Turn on both TWTs and adjust phase shifter to obtain maximum power at TP8 (approximately -3 dBm). __________ dBm

i) Rotate TONE-VOICE switch on upconverter to TONE position. Note that there is no measurable change in output power at TP8.

2) Power Output Measurement

a) Turn off both TWTs and connect antenna in place of dummy load. Turn on TWTs and observe that there is no measurable change in power. ____________ dBm

b) To measure power input to transmit antenna, connect test equipment as shown in Figure A-1.

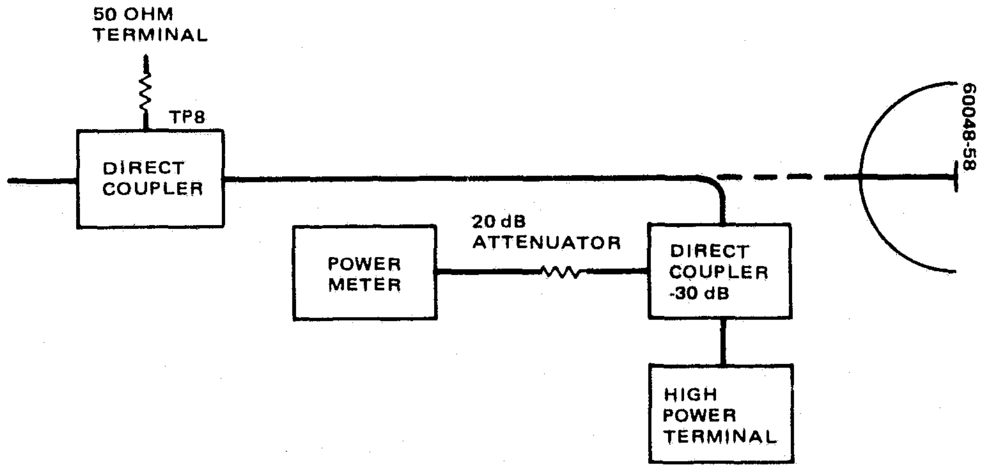


FIGURE A-1

c) Power input to antenna should read a minimum of +46.5 dBm.

Direct coupler ______________ dB

Fixed Attenuator ______________ dB

Power meter reading ______________ dB

(Total) Power input to antenna = ________ dBm

Transmit antenna gain = __________ dB

EIRP = __________ dBm

A.2.4 Carrier-to-Noise Measurement (HP 141)

This measurement will be performed using an HP 141 spectrum analyzer. The system input carrier level will be the nominal -106 dBm at the input to the low noise amplifier AR1 in the receiver and downconverter unit.

1) TP1 Test Input Calibration - In order to establish a level of -106 dBm at AR1, the test input insertion loss must be measured from TP1 to AR1.

a) Configure test equipment as shown in Figure A-2. Set frequency of signal generator to 1684 MHz. Set RF level to 0 dBm. Set HP 394A attenuator to -40 dB. Adjust the sensitivity of HP 141 to obtain an RF level reference.

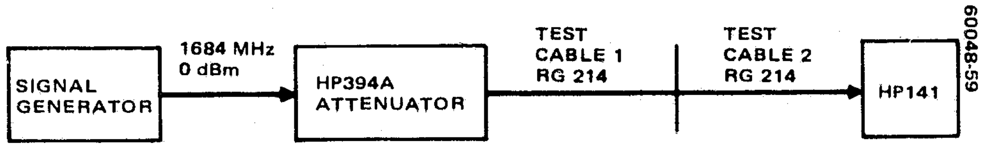


FIGURE A-2

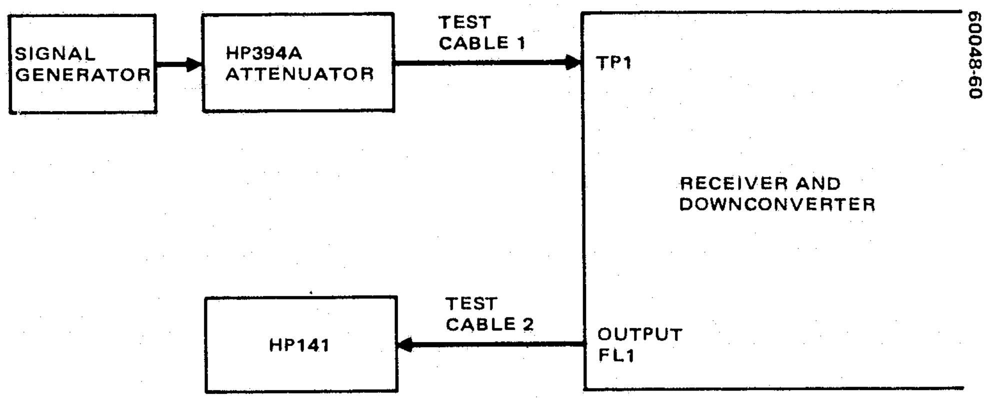


FIGURE A-3

b) Connect test equipment as shown in Figure A-3. Adjust variable attenuator to obtain same RF level on HP 141 as was measured in previous step. Subtract attenuator reading from 40 to obtain test input insertion loss. __________ dB

c) Subtract value recorded in previous step from -106 dB to obtain level required at TP1 to simulate nominal system carrier level. This level will be referred to as NOMINAL TEST LEVEL. Record this level on TARS block diagram. __________ dBm

A. 2. 5 Carrier-to-Noise Measurement (HP 394A)

1) Set frequency of generator to 1684 MHz.

2) Connect test equipment as shown in Figure A-4. Set HP 394A attenuator to 10 dB. Adjust level output of signal generator to obtain a reading of -10 dBm on power meter.

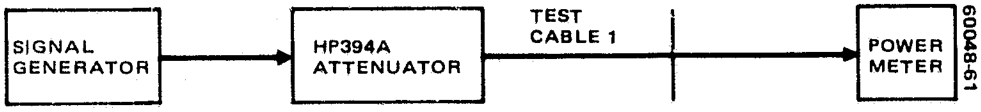


FIGURE A-4

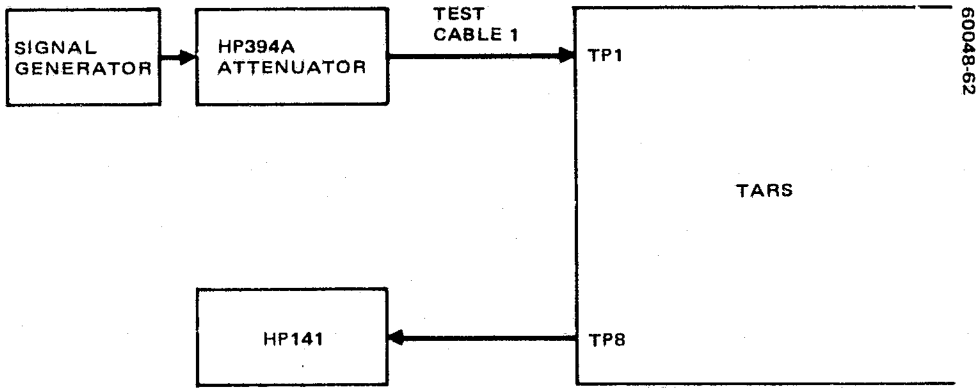


FIGURE A-5

3) Adjust HP 394A attenuator to value of the NOMINAL TEST LEVEL. Connect test cable 1 to TP1 as shown in Figure A-5. Connect HP 141 spectrum analyzer to TP8. Adjust fine frequency of signal generator to obtain an optimum carrier-to-noise ratio as observed on spectrum analyzer. Set video bandwidth of spectrum analyzer to 10 kHz. Measure noise level relative to the known carrier level of -106 dBm. Noise in 10 kHz band should be a minimum of -28 dBc. ______________ dBc

A. 2. 6 Measurement of TARS Delay

This measurement will be performed using test equipment as shown in Figures A-6 through A-9. The TARS delay is measured by using a 200 kHz ranging tone and the total calculation will be taken from the antenna focal points. The resultant delay should approximate 1.1 seconds. The first part of the measurement determines the delay of the test equipment; this will later be removed from the total measurement.

1) Test Equipment Delay

a) Connect equipment as shown in Figure A-6. Turn off power from tone processor so that only carrier is present on output of tone modulator. Make an initial setting of 10 dB on the variable attenuator.

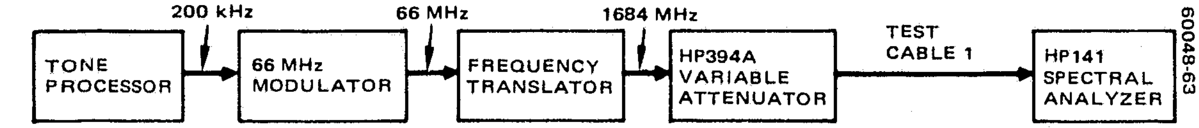


FIGURE A-6

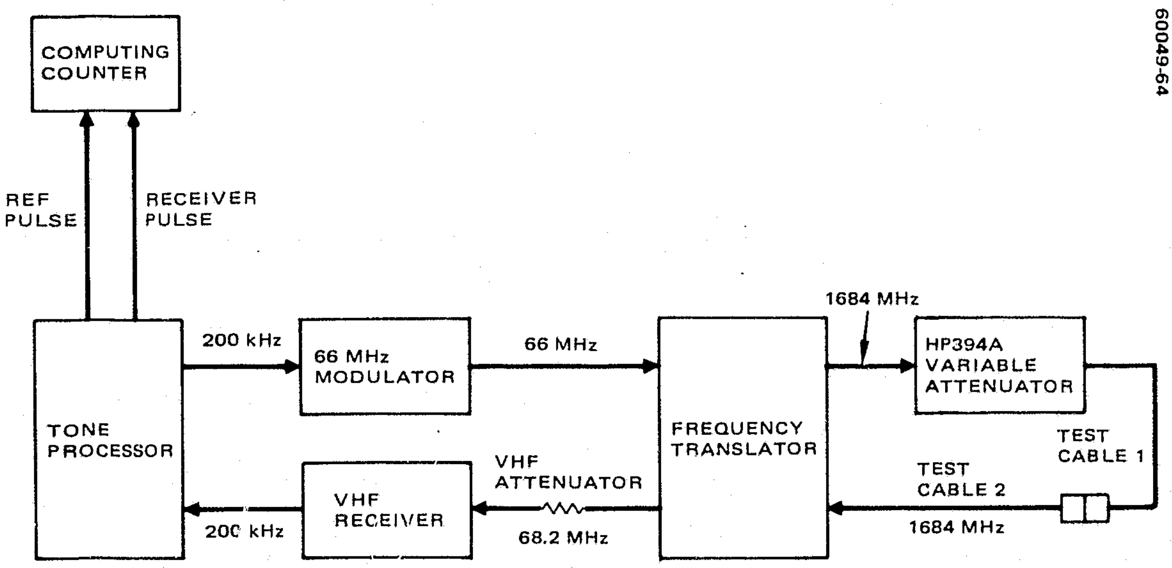


FIGURE A-7

b) Connect HP 141 spectrum analyzer to output of variable attenuator. Monitor carrier at 1684 MHz. Turn on tone processor and check that modulation index is 1.4. (Carrier and first sideband pair is equal in level.)

c) Connect test equipment as shown in Figure A-7. On frequency translator, place CALIBRATE-TARS switch to CALIBRATE position. Adjust VHF attenuator to obtain a signal strength of -80 dBm as monitored on receiver. Adjust computing counter to average 10^4 time intervals. Record delay of test equipment. ______________ ns

d) Set variable attenuator to approximately 100 dB. Connect test equipment as shown in Figure A-8. Remove modulation from tone modulator. With spectrum analyzer connected to TP8 on the TARS, adjust variable attenuator to obtain a C/N_o of 68 dB as monitored on spectrum analyzer.

e) Connect equipment as shown in Figure A-9. On computing counter, measure total delay of test setup. ____________ ns

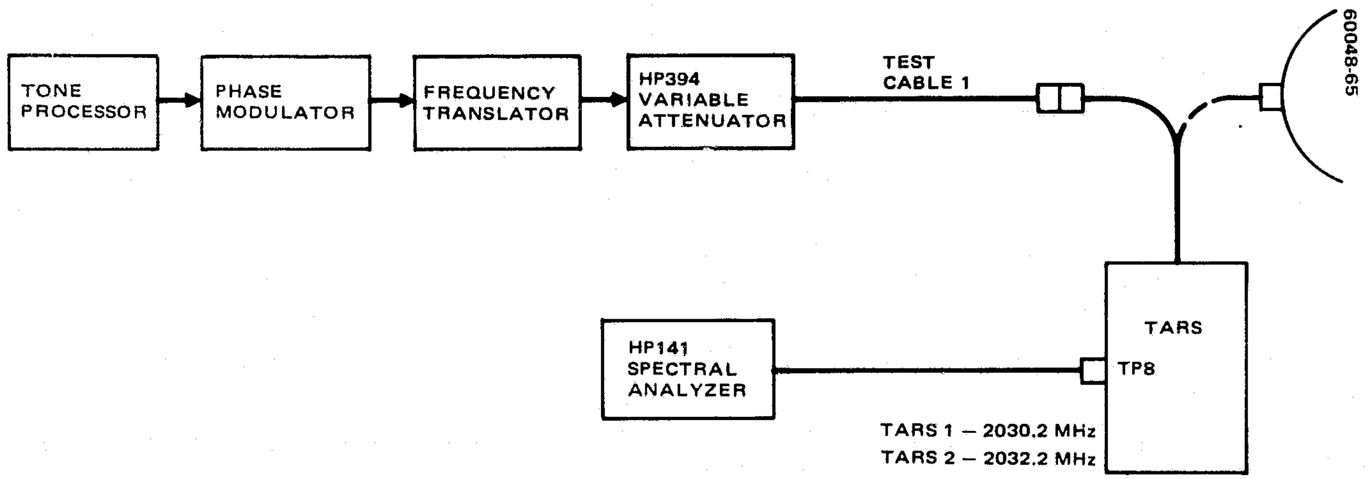


FIGURE A-8

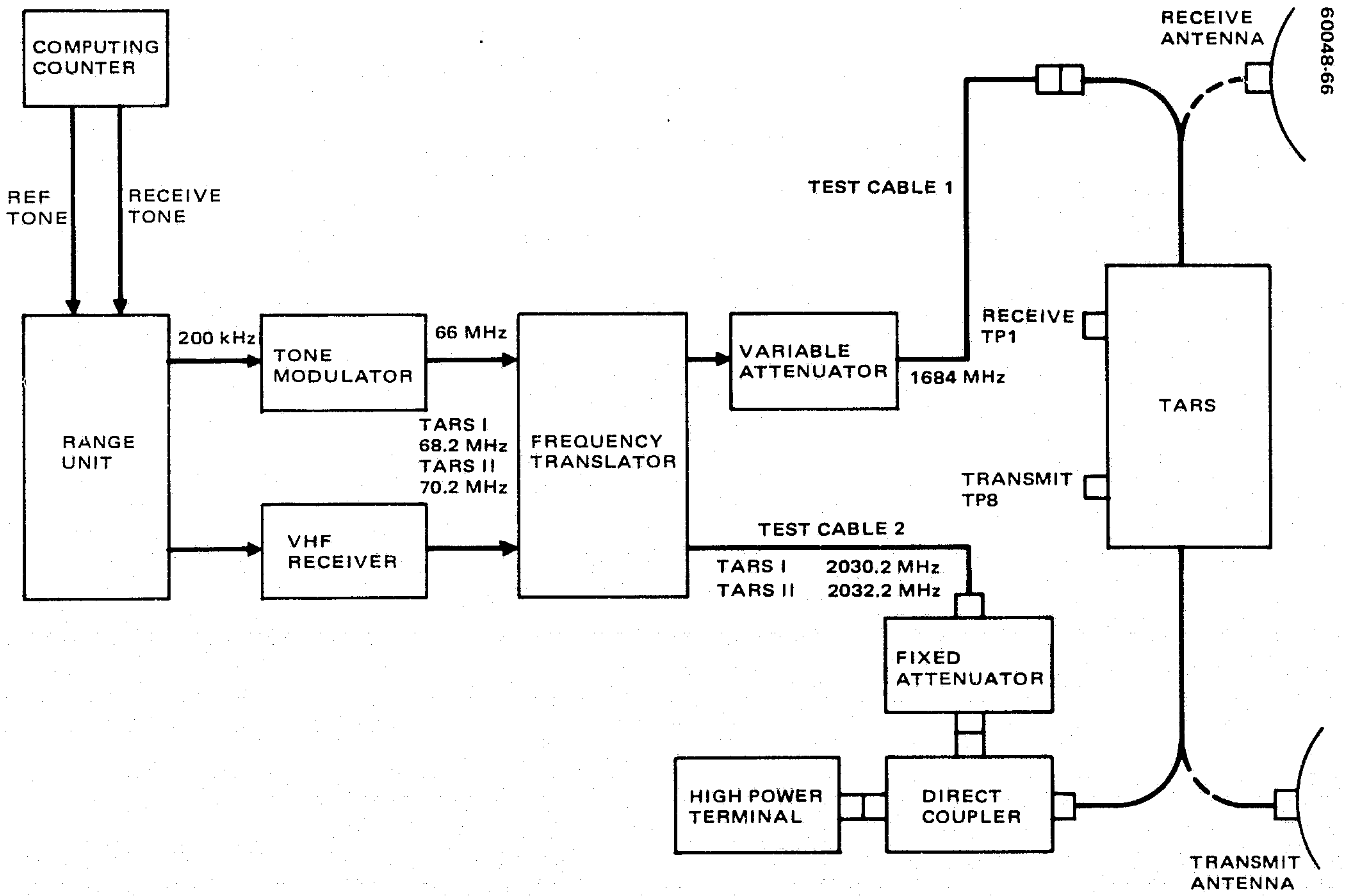


FIGURE A-9

f) Determine TARS total delay as follows:

Total delay ______________________ ns

Calibrate loop ______________________ ns

Direct coupler plus attenuator ____2.0____ ns

Antenna focal point delay ____20.8____ ns

TARS delay ______________________ ns

A.2.7 Command Threshold Measurement

This procedure will determine the carrier level required to reliably command the TARS transmitter.

1) Connect test equipment as shown in Figure A-10.

2) In tone modulator test unit, switch to orderwire function.

3) Connect an audio oscillator to modulator input and adjust frequency to applicable command tone for TARS under test. Set modulation in modulator for a 6 dB BW of 30 kHz.

4) Attenuate carrier level until RF AMPLIFIER GATE lamp will still reliably gate on and off for 10 consecutive gatings of command tone. Record this level. ____________ dB/10 kHz BW

5) At a receive carrier level of -100 dBm, observe that command receiver will not gate at other TARS command frequencies.

Range system I,	TARS 1,	2940 Hz
Range system I,	TARS 2,	3180 Hz
Range system II,	TARS 1,	3625 Hz
Range system II,	TARS 2,	3925 Hz

6) Record YES/NO. ______________

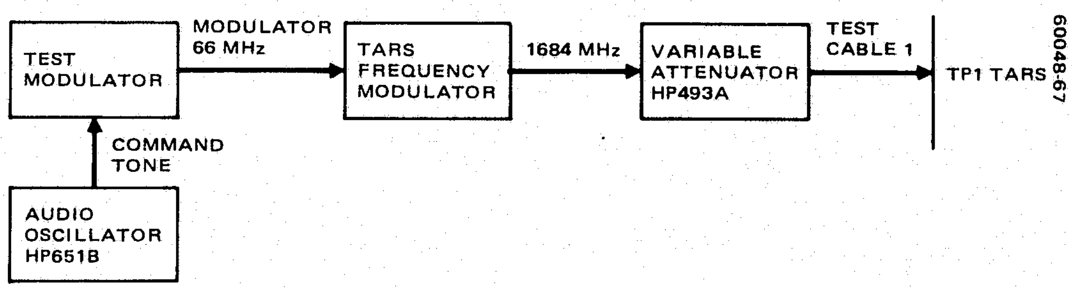


FIGURE A-10

A. 2. 8 Orderwire Performance

The first part of this test will measure the orderwire ring receive and transmit performance; the second portion will measure voice reception threshold and check the transmission spectrum.

1) Orderwire Ring Receive and Transmit

a) Configure test equipment as shown in Figure A-5.

b) Set frequency of audio oscillator to 4525 Hz. Observe 70 MHz output of test modulator on a spectrum analyzer and adjust 6 dB BW for 60 Hz.

c) Reconnect test modulator to frequency translator. With repetitive keying of audio oscillator, decrease carrier level until orderwire buzzer will no longer reliably ring. Record this level. ______________________ dB Hz

d) On TARS upconverter, switch modulation selector from TONE to VOICE.

e) Monitor 70 MHz output of VCO on a spectrum analyzer. While transmitting an orderwire ring tone, check that transmitted BW is 12 kHz. Adjust if necessary. ______ kHz

2) Voice Reception and Transmission

a) To check performance of TARS voice reception, connect a headset in place of audio oscillator shown in Figure A-10. Adjust modulation for a BW of 60 kHz at normal voice level. While monitoring orderwire headset, decrease carrier applied to TARS. Record minimum carrier level at which voice is still discernible. ______________________ dBm

b) Monitor 70 MHz output of orderwire VCO on a spectrum analyzer. Conduct an orderwire voice transmission test and note that audio BW does not exceed 12 kHz.

A. 2. 9 TARS - CDA Link Measurements

After optimizing, the antenna angles and polarizations, the receive carrier levels should be recorded for the TARS and CDA.

1) TARS Receive Level - While in voice communication with the CDA at Wallops, increase the carrier transmitted from the CDA until any further increase results in no C/N_o improvement at the TARS. Monitor TP8 with a spectrum analyzer and determine the C/N_o.

   CDA transmit level ____________________ watts

   TARS C/N_o ____________________ dB Hz

2) CDA Receive Level - With the CDA transmitting the same level as above, record the C/N_o monitored at the CDA. Again monitor the TARS transmit level.

   TARS transmit level ____________________ dBm

   CDA C/N_o ____________________ dBm Hz